

PRICE EFFECTS OF FINANCIAL FUTURES TRADING

BY

DAVID COHEN

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By

David Cohen

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Chairman: Arnold A. Heggestad  
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There has been much concern voiced over the possible spot market volatility effects of the new financial futures markets, particularly in a study by the Federal Reserve Board and the Treasury Department regarding Treasury instrument futures markets. This study is designed to provide evidence on the spot price volatility effects of futures trading in 90-day Treasury Bills. The method of analysis is to first identify periods of time that are roughly similar in their overall capital market volatility, but differ in that one period is before TBill futures trading began and its comparable period is after TBill futures trading began. Next several econometric techniques are used to estimate models of interest rate determination. The estimation produces measures of spot TBill rate

volatility for each of the comparable periods which are then used in a pairwise fashion to ascertain the spot price volatility effects of futures trading.

The interest rate models come from the rather large body of macroeconomics literature dealing with the formation of interest rates. The econometric techniques span different assumptions imposed on the models and each technique provides consistent estimates of the model parameters under the stated conditions. Further, simple analysis of daily and weekly TBill rates is performed to provide continuity with studies of futures market spot price effects in other commodities.

The results of all the statistical tests suggest that Treasury Bill futures trading does not increase spot market volatility during relatively stable periods of capital market activity, but is associated with increased spot Treasury Bill market volatility during times when overall capital market conditions are volatile. These results indicate that Treasury Bill futures trading alone does not increase spot market volatility, contrary to the hypothesis that simply the existence of financial futures trading destabilizes the underlying spot market.

## CHAPTER 1 INTRODUCTION

### Background

Futures trading in financial instruments is a fairly new occurrence--trading began in October 1975 at the Chicago Board of Trade in Government National Mortgage Association (GNMA) futures contracts. Since then, financial futures trading has grown very quickly, both in volume of trading and in types of instruments traded. At least five futures exchanges now offer trading in some type of financial futures contract (Chicago Board of Trade (CBOT), International Monetary Market (IMM) of the Chicago Mercantile Exchange (CME), Amex Commodities Exchange, Commodity Exchange, Inc., and New York Futures Exchange), such as 90-day and one year Treasury Bonds, 30-day Commercial Paper, and two types of GNMA certificates. Various futures exchanges in the U.S. also have requests before the Commodity Futures Trading Commission (CFTC) to open trading in more financial futures. Volume figures for one of the most successful contracts, the IMM's 90-day TBill contract range between 3,000 and 4,000 contracts per day.<sup>1</sup> The CBOT's long-term TBond futures traded over 2 million contracts in 1979. The range of contracts offered and trading volumes

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<sup>1</sup>CME Statistic. Note that each contract is for \$1 million face value of TBills.

indicate that financial futures have a place in the current economic environment.

The rapid growth of trading and proliferation of contracts across exchanges has not been well received in all quarters. Particularly, the Treasury Department and the Federal Reserve System are alarmed at the potential impacts of financial futures trading on their activities. A lengthy report, the Treasury/Federal Reserve Study of Treasury Futures Market, cited the following concerns with the Treasury Bill (TBill), Treasury Note, and Treasury Bond (TBond) futures contracts:

1. Will there be an increase in spot interest rate volatility from futures trading? Such an increase in volatility could increase the cost of government debt financing.
  2. Will the Treasury feel compelled to issue securities simply to avoid "squeezes" or "corners" in the corresponding futures market?
  3. Can the exchanges and the CFTC effectively police these markets to avoid attempts at manipulation?
- (Treasury/Fed, 1979).<sup>2</sup>

The present study addresses the first of these issues. Particularly, an empirical investigation of the impact of

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<sup>2</sup>The second and third issues are the subjects of a paper by Phillip Cagan (1981).

financial futures on the underlying spot markets in TBills will be conducted. This is intended as a response to the Treasury/Fed concern:

that futures trading in Government securities will have a destabilizing effect on prices in spot markets for these securities and that investors on whom the Treasury normally relies to finance its debt may be dissuaded from bidding in Treasury auctions if prices become less stable, thus leading to higher yields or costs to the Treasury. (Treasury/Fed, 1979, pg. 11)

The Treasury/Fed position is of great interest to all potential and current users of financial futures markets (as well as the exchanges themselves) since the CFTC is withholding approval for some new contracts until the Treasury/Fed are assured of no ill-effects, and could withdraw approval for existing contracts if these agencies present arguments against such futures contracts. Given the apparent market acceptance of financial futures trading, careful analysis of the impact of these markets on the spot markets is important to many economic agents. Thus the empirical investigation carried out in this study is of interest to the regulatory agency for futures trading, the Fed, the Treasury Department, futures exchanges, and financial futures traders and potential traders.

This study is designed to provide evidence on the spot price volatility effects of futures trading in 90-day Treasury Bills. The method of analysis is to first identify periods of time that are roughly similar in their overall



capital market volatility, but differ in that one period is before TBill futures trading began and its comparable period is after TBill futures trading began. Next several econometric techniques are used to estimate models of interest rate determination. The estimation produces measures of spot TBill rate volatility for each of the comparable periods which are then used in a pairwise fashion to ascertain the spot price volatility effects of futures trading.

The interest rate models come from the rather large body of macroeconomics literature dealing with the formation of interest rates. The econometric techniques span different assumptions imposed on the models and each technique provides consistent estimates of the model parameters under the stated conditions. Further, simple analysis of daily and weekly TBill rates is performed to provide continuity with studies of futures market spot price effects in other commodities.

The question of spot price volatility effects from futures trading has been raised in other futures markets, particularly onion and potato futures. Extensive Congressional hearings led to Public Law 85-839 (1958), which prohibits futures trading in onions, and although the potato futures has not been closed by Congress, it has three times been subjected to Congressional scrutiny (85th, 88th, and 89th Congresses). It is clear that adverse opinion can close futures markets and it is important that such

opinion be founded on carefully collected empirical fact, not on heresay or inappropriate statistics. See Working (1960) on the evidence presented to Congress regarding onion futures.

This study focuses on one of the new Treasury instrument futures markets, 90-day TBills. This futures contract is the most important (volume-wise) of the Treasury futures and one of the most successful contracts ever traded on a futures exchange. Its success makes it the obvious choice for the type of analysis presented here. An interesting extension of this study would be to apply the methodology, with appropriate modifications, to the other Treasury instrument futures.

In the remainder of this first chapter the fundamentals of futures markets and futures trading will be presented. Chapter 2 will review the theoretical arguments regarding spot price volatility effects of futures trading. In Chapter 3 the previous empirical work on this question is presented. Chapter 4 explains the methodology used in this study and presents the results. Chapter 5 contains the summary and conclusions from the results.

### History and Development of Futures Trading

Futures trading is a very old form of commerce. In the United States, organized trading in futures contracts

dates back over one hundred years, but in other countries futures trading existed over three hundred years ago. Futures trading developed in Europe during the seventeenth century medieval fairs, and probably earlier than this in Japan and Holland. The Chicago Board of Trade (CBOT) is the oldest commodity exchange in this country to have supported futures trading. The CBOT, originally established as a market place for grading, weighing and trading physical commodities (grains), sanctioned trading in standardized contracts for forward delivery in 1865, along with rules governing margins, terms of payment and terms of delivery.

Today there are at least twelve exchanges on which futures trading takes place in the U.S. alone. In some years the volume of trading on the CBOT, the largest exchange, exceeds the dollar volume of trading in stocks on the New York Stock Exchange. Most modern exchanges are organized as non-profit membership corporations, ruled by committees of trading members, and assisted by paid professional staff. The exchanges do not participate in trading or in the influencing of prices in any way. The exchanges are meeting places for the trading conducted by these members for their own account and the accounts of others. The exchanges are financed by fees and dues, as well as other business enterprises such as renting space and investments in portfolios of assets.

According to Working, futures markets developed where a strong demand for hedging existed (Working, 1953b). This is evidenced by data showing that the volume of open interest in grains moved with the volume of grain held commercially, and likely to be hedged.<sup>3</sup> Further, across commodities, the open interest varies with the amount of the commodity that is hedged. Successful introduction of a contract therefore, may depend on the amount of hedging interest that is attracted. But there is a two-way connection: the liquidity of a market is improved by a large volume of speculation, so to the extent that hedging costs are lower the more liquid is the market, hedging and speculating should be viewed as jointly supporting the success of a particular contract.

In Chicago in the middle 1800's the demand for hedging by merchants, warehousemen and processors of grain was strong enough to make futures trading viable. Farmers in the fertile areas around Chicago were producing crops far in excess of local need. But without good transportation facilities and storage facilities, grain rotted after harvest and was scarce before the next harvest. Forward contracts soon developed to stagger the arrival of grain at the Chicago markets. With the opening of rail and barge

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<sup>3</sup> Open interest is defined as the number of futures contracts entered into and not liquidated by delivery or an offsetting futures market transaction.

transportation, Chicago's prominence in the grain trade increased. Those persons dealing in forward contracts found them to be less than perfect instruments for trading due to several factors:

- a. The contracts were not for standardized qualities and hence not very liquid.
- b. Deliveries were unreliable.
- c. Payment methods varied.

All of these factors caused the eventual development of the standardized, guaranteed contracts that are today traded on the organized futures exchanges. These contracts are highly liquid and traded in an open, competitive bidding atmosphere, which makes them more suitable for the role they play in the marketing activities of most hedgers as well as for most speculators.

Today active trading in futures contracts for over fifty commodities exists; examples are interest rate futures (Treasury Bills, commercial paper, Treasury Bonds, GNMA's), foreign currencies, lumber and plywood, grains, porkbellies, metals, beef, and frozen concentrated orange juice (Commodities, 1979). Some of these commodities have nine different contracts for delivery in nine different months (e.g., gold), while some have fewer (e.g., oats on the CBOT are traded in only four contracts, May, July, September and December). Organized exchanges are located in New York, Chicago, Kansas City, London, Paris, Singapore, and

several other cities. Primary credit for the growth in number of exchanges and number of commodities, as well as the growth in volume, must go to the technological developments in communications. The virtually instantaneous and low cost transmission of trading data has reduced the costs of trading dramatically since the origin of futures markets, thus broadening the scope of useful participation in this marketing institution. Futures exchanges today are large, efficient, growing institutions with emphasis on safety and innovations in trading.

Since the inception of futures trading, public distrust and misunderstanding has been evidenced by repeated attempts at government intervention. In 1916 the Cotton Futures Act was passed and in 1922 the Grain Futures Act was passed, bringing futures trading under government regulation. In 1930 the Grain Futures Act was amended to become the Commodity Exchange Act, which established the Commodity Exchange Authority (now called the Commodity Futures Trading Commission) to be the government's agent in the regulation of all aspects of futures trading.<sup>4</sup> This agency may provide a valuable service to the futures trading industry by reassuring the public of the government's interest in the safety of their commitments and transactions in futures markets.

The financial futures markets began in October 1975 when the CBOT opened trading in GNMA pass through

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<sup>4</sup> Another important piece of legislation is Public Law 85-839 (1958) which prohibits futures trading in onions.

securities.<sup>5</sup> Very shortly thereafter, in January 1976, the IMM opened trading in 90-day TBills. The CBOT followed with 90-day commercial paper and long term TBond contracts in 1977. Later other exchanges opened trading in various financial instruments, sometimes in direct competition with existing contracts (Commodity Trading Manual, 1980).

Generally, these financial futures contracts follow the same pattern of trading rules as other futures contracts. However, some contracts specify a delivery date, a single day, rather than a delivery month, for the delivery and settlement of contracts positions not closed out by reversing transactions.<sup>6</sup>

### Introduction to Trading

In this section a brief discussion of trading mechanics will be presented, along with descriptions and examples of hedging, speculating and spreading.

It is best to introduce futures trading by describing what futures trading is and why futures contracts are different from other forms of forward delivery contracts. Futures trading is "trading conducted under special regulations and conventions, more restrictive than those applied to any other class of commodity transactions, which serves

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<sup>5</sup> Actually trading is in Collateralized Depository Receipts for GNMA's.

<sup>6</sup> See Powers (1973), Hieronymus (1971), Venkataramanan (1965), and Goss and Yamey (1976) for more detail on the history and development of futures trading.

primarily to facilitate hedging and speculating by promoting exceptional convenience and economy of transactions"

(Working, 1953b). This definition requires elaboration.

Futures trading is trading in commodities for future delivery, to be made at the maturity date, with payment to be made upon delivery of the commodity, the price of such futures commodity transaction determined at the date of contract for delivery is entered, with no exchange of money occurring at the time of agreement.<sup>7</sup>

Futures contracts are the vehicles for such agreements. They are standardized, legal contracts between two parties (one of whom is always the commodity exchange clearinghouse). A person who wishes to own the commodity later is called the buyer, while the person who wishes to make delivery later is called the seller. Thus the buyer profits from a price increase, the seller from a price decline.<sup>8, 9</sup>

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<sup>7</sup>For most futures contracts this "date" is the entire month that the contract matures in. For example, delivery of wheat on a December contract can occur at any time in December, the exact date being the seller's option. For many interest rate futures (TBills on the CBOT for example) the maturity date is a particular day.

<sup>8</sup>In reality, very few contracts are settled by delivery; rather the parties typically reverse their positions before the close of trading on their contracts. The last sentence above is a better description of "buyers" and "sellers."

<sup>9</sup>In commercial paper futures contracts, the short, or seller, is obligated to deliver a cash loan while the long, or buyer, is obligated to deliver contract grade commercial paper. In this market, the seller benefits from a



The buyer is said to be "long" and the seller is said to be "short" in the futures market, just as an owner of physical goods is "long" the goods while a person who has forward contracted to deliver goods he currently does not own is said to be "short" the goods.

While the definition by Working given above did little to illuminate the nature of futures trading, it serves well for distinguishing futures trading from other types of forward purchases and sales. Many people are familiar with forward transactions--the purchase of a home or car for example, typically is not consummated in a day. Possession of the home or car does not immediately follow the transaction. Perhaps full or partial payment is made before delivery, or perhaps the purchase is C.O.D. In business, formal forward contracting is usual, wherein two parties negotiate for the delivery of a certain item at a certain time, place and price, with the posting of some performance bond and agreement as to remedies for non-performance. Such agreements are formal forward contracts, but they are not futures contracts, nor are they instances of futures trading. As the definition states, futures trading takes place on organized exchanges, during certain hours, by open outcry, subject to government regulation. This trading takes place

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<sup>9</sup>fall in interest rates (a rise in price). This maintains the usual cash market relationship of discount rate changes to long and short positions.

only for the quantity, quality and type of commodity stated in the highly standardized futures contract that the exchange deals in. Contracts are further standardized with respect to delivery location, method of payment and time of delivery. Thus futures trading and futures contracts are distinguished by the rigid standardization and regulation of the commodity involved and the method of trading. By contrast, forward contracts are "personalized" to the needs of the contracting parties, and negotiated privately (Working, 1960).

### Speculating

Speculation in futures markets means the assumption of risk of price movements in a commodity, for which the speculator has no physical use. The speculator takes a long position (is said to "buy a contract") when he believes that the futures price will rise. If it does rise, when he reverses his long position by "selling a contract" at the higher price, he profits. The difference in price times the number of units traded is the speculator's profit, less the trading commission. Algebraically, for a long position,

$$\text{profit}_{\text{long}} = \left[ P_{t+n,h}^f - P_{t,h}^f \right] \cdot \left[ \frac{\text{number of units}}{\text{per contract}} \right] \cdot \left[ \frac{\text{number of contracts}}{\text{contracts}} \right]$$

where  $P_{t,h}^f$  is the price of a futures contract at time  $t$  for delivery at time  $h$  (the price paid) and  $P_{t+n,h}^f$  is the price

of the same contract  $n$  periods later (the price received). For an opening short position, the profit is the negative of the long position:

$$\text{profit}_{\text{short}} = \left[ p_{t,h}^f - p_{t+n,h}^f \right] \cdot \left[ \frac{\text{number of units}}{\text{per contract}} \right] \cdot \left[ \frac{\text{number of contracts}}{\text{contracts}} \right]$$

Some examples of speculation follow:

- (1) A speculator takes a long position in two soybean contracts at a price of \$5.15 per bushel. Two weeks later he 'closes' his position by selling two contracts for \$5.18 per bushel. Since a soybean contract is for 5,000 bushels (on the CBOT), he has earned a profit before commissions of three cents per bushel or  $(\$0.03)(10,000) = \$300$ .
- (2) A speculator sells one contract in 4-year Treasury Notes (on the IMM) for 90-12 (price is in percentage of par, denominated in 64th's). Some weeks later, but before the maturity date, she closes her position by purchasing one contract for 91-12. Since the contract size is \$100,000 face value, her profit is  $-(1\%)(\$100,000) = \$1,000$ , a loss of \$1,000.

In the definition of futures trading given above, it was stated that no money is exchanged at the time the agreement is entered. However, a performance bond must be deposited with the member through whom the individual's trading is conducted. This deposit has the misleading name 'margin.' Both the long and the short must post margin.

Each day the individual's margin account is credited or debited by the amount of profit or loss for that day in his position. This is called "marking to market." Should the margin account fall too low (below the maintenance margin level), the individual receives a margin call. Conversely, the individual may withdraw excess margin. Minimum margins are set by the exchange offering the contract; typically margins are five to fifteen percent of the contract value.<sup>10</sup> Margins are set so low due to the daily resettlement procedure and the fact that exchanges set limits on the amount of price change that will be tolerated each trading day. If a contract's price "moves the limit," further trading is suspended for that day.<sup>11</sup> Daily resettlement and limits on daily price changes mean that a low margin, or rather a low performance bond, will serve to remove the private incentive of traders to default on contract obligations.<sup>12</sup>

### Hedging

In its textbook sense, hedging involves the initiation of simultaneously offsetting positions in the actual

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<sup>10</sup> Individual brokers set their own margins for their customers. Typically these are significantly higher than the required margin set by the exchange, and they vary depending on the customer-broker relationship.

<sup>11</sup> "Variable limits" go into effect if a commodity's price moves the limit on three consecutive days. These limits are generally 150% of the original limits.

<sup>12</sup> Margin requirements may often be satisfied by depositing interest-bearing securities (e.g., U.S. Treasury Bonds) with the trader's broker, rather than cash. See Sandor (1976) for more details on speculative activity.

commodity and the futures contract for that commodity. The goal of such a strategy is to eliminate any price risk associated with inventory held (short hedging), or with input needs (long hedging). This section will discuss the mechanics of this textbook approach to hedging in financial futures. For a broader and more complete description of hedging behavior see Working (1962).

Short hedgers in financial futures are those whose actuals position would be adversely affected by a rise in interest rates (a fall in bond prices).<sup>13</sup> If interest rates rise, prices of financial futures contracts fall, so a short position in futures profits. This offsets the loss in the hedger's commercial business due to the rise in rates. Banks, insurance companies and corporations with current holdings of bonds, corporations with future borrowing needs, banks that will be selling Certificates of Deposit (CD's), builders with up-coming mortgage needs are all examples of firms with short hedging possibilities.

Long hedgers are those whose profits would be reduced if there was a fall in interest rates (a rise in bond prices). If interest rates fall, futures prices of financial instruments will rise, so a long position would gain if interest rates fall. This gain on a long futures position would offset the adverse impact of a fall in rates

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<sup>13</sup> Note that the definitions of long and short positions are reversed for commercial paper futures contracts.

on the long hedger's commercial business. Insurance companies and pension funds with regular futures inflows of cash to be invested in financial investments could hedge the risk of declining yields with a long futures position. Securities dealers with forward commitments to deliver bonds or bills at fixed prices could also hedge the risk in their short actuals position with a long futures position.

As an example of a long hedge in interest rate futures, consider an insurance company executive that expects a cash inflow of about \$100,000,000 in one month.<sup>14</sup> This money will be invested in long term U.S. Treasury Bonds, currently yielding 8.42% on 20 year, 8% bonds. This is a current market price of \$9,600,000 for \$10,000,000 face value of the bonds. Fearing a decline in yields over the month-long period until he can purchase the bonds, he takes a long position of 100 contracts in long term TBond futures on the Amex Commodities Exchange at a price of 95-08 (\$9,525,000 for \$10,000,000 face value) or a yield of 8.57%.<sup>15</sup> By month end, yields have declined to 8% on the cash market for 20 year, 8% TBonds (selling now at par = \$10 million), while the future price has risen to 99-08 (\$9,925,000). The gain in the futures position offsets exactly the increased cost (lowered yield) of the actual

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<sup>14</sup>This example is drawn upon a nearly identical one presented by F.D. Arditti in a set of notes on futures contracts.

<sup>15</sup>Prices are stated in percentages of par. 95-08 is 95 and 8/32% of par = \$9,500,000 plus 8/32 of 1% = \$9,525,000.

TABLE 1  
LONG HEDGING EXAMPLE

	<u>Cash Market</u>	<u>Futures Market</u>	<u>Basis*</u>
Current Time	Cash market yield of 8% 20-year bonds is 8.42% (96-00, or \$9,600,000 for \$10,000,000 face value)	Futures price is 95-08 (\$9,525,000 for \$10,000,000 face value), or a yield of 8.5%. Buy 100 contracts	0-24 or \$75,000
One Month Hence	Cash market yield declined to 8% (100-00, or \$10,000,000 face value). Buy \$10,000,000 worth of TBonds	Futures price rose to 99-08 (\$9,925,000); yield declined to 8.09%. Sell 100 contracts	0-24 or \$75,000

Opportunity loss = \$40,000      Gain = \$9,925,000 - \$9,525,000  
by waiting one month                      = \$40,000

Basis change = 0      Net cost of bonds = \$10,000,000 price  
                                    paid less \$40,000 gain in futures =  
                                    \$9,600,000.

Net yield to maturity is 8.42%.

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\* Basis is defined as cash price minus futures price.

bonds, as detailed in Table 1. The net cost of bonds is \$9,600,000, or a net yield to maturity of 8.42 %.

The example details a highly simplified hedging operation. The hedge worked 'perfectly' in that futures price movements exactly offset cash market price movements. Thus the cash price and yield at the time the hedge was placed were the same as the net price and yield at the time the hedge was lifted. Such an outcome is rarely observed, and a short-hand method of describing and predicting hedging outcomes is used to handle more realistic (complicated) hedging opportunities. The basis is defined as the difference between the cash price and a particular contract's futures price, at some point in time. The basis column in Table 1 shows the basis at the two trading times in the long hedging example. In that example, the zero change in the basis resulted in a realized price equal to the initial price. The basis change then shows the difference between the realized price and the initial price.

Another example, this one for a short hedging operation, will further illustrate the basis and its importance.

Suppose a firm expects to have need for about \$1,000,000 in short-term capital in one month, and so is planning to borrow on a discount basis at a commercial bank. The bank charges the firm 1% above the prime rate current at the time of the loan. The prime rate now is 11%, so the firm would receive \$970,000 for a 90-day note promising



to pay \$1,000,000.<sup>16</sup> The firm fears a rise in rates and so hedges its future need for funds by selling a 90-day TBill contract on the IMM at the current futures price of 88-00. This price is the IMM Index, which is the difference between 100 and the annual discount on TBills. The market value of this contract is then

$$(\$1,000,000)(1.00 - .12(90/360)) = \$970,000$$

One month later, the firm borrows \$1,000,000 at a discount rate of 13%, for a loan proceed of \$967,500. The firm buys back its futures contract at the current IMM Index of 87.6 (or a market value of \$969,000). As Table 2. details, the firm's net cost of borrowing is 12.6%, or a loan proceed of \$968,500. The basis changed from zero at the start of the hedge, and declined to -0.4 (or -\$1,000) when the hedge was lifted.

If the basis had remained at its initial value, (zero in this case), the hedge would have worked perfectly, as in the example in Table 1. However, the basis here moved against the short hedger--the cash price declined relative to the futures price--and so the short hedger "lost." Of course, his gain in the futures market partially offset his opportunity loss in the cash market, so the hedge had some success. If the hedger was actively and accurately

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<sup>16</sup>The bank charges 12% to the firm, which is a 3% quarterly rate, or a discount of \$30,000 on 1,000,000 principal.

TABLE 2.  
SHORT HEDGING EXAMPLE

	Cash Market	Futures Market	Basis*
Currently	The firm recognizes a future need for about \$1,000,000 in one month. Could borrow at 12% (discount) today. \$970,000 proceeds, IMM index = 88.0.	Firm sells one futures contract at 88.00. Market value = \$970,000, implies rate is 12%.	0.00 or \$0
One Month Hence	Firm borrows from bank at 13%. Proceeds = \$967,500. IMM Index = 87.00.	Firm buys back its futures contract at 87.00, or a market value of \$969,000	-0.4 or -\$1,000

Opportunity Loss = \$2,500      Gain = \$1,000

Net proceeds = \$967,500 plus \$1,000 gain = \$968,500.

Net cost of borrowing (annualized discount) = 12.6%.

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\*Basis is defined as cash price minus futures price.

forecasting the basis at the initiation date of the hedge, a net 12.6% borrowing cost might well have been what he was trying to achieve.

If the basis would have improved, that is if the futures price would have fallen by more than the cash price (say to 86.40) the short hedger would have "profited" (by \$1,500 = futures gain (\$4,000) - opportunity loss (\$2,500)). His cost of borrowing would have been less than the original 12%;  $11.4\% = [\$1,000,000 - 971,500 \text{ net proceeds}] \times \frac{4}{1,000,000} \times 100\%$ .

Algebraically, the net proceeds received (net price received) by a person engaged in a short hedge is

$$\text{net proceeds} = \frac{\text{final cash}}{\text{proceeds}} + \left[ \frac{\text{initial futures}}{\text{value}} - \frac{\text{final futures}}{\text{value}} \right] .$$

By adding and subtracting the initial cash price,

$$\text{net proceeds} = \frac{\text{initial cash}}{\text{price}} + \text{final basis} - \frac{\text{initial}}{\text{basis}} .$$

The formula gives the net price paid by a long hedger, since the price he pays must be the price received by the short hedger, who takes the opposite side of the transactions (this assumes no trading costs).

This formula makes clear that a narrowing basis hurts the short hedger, while a widening basis improves his position. Prediction of basis changes, rather than interest rate (price) changes, becomes important as the hedger trades in price risk for basis risk. Hedging operations which

take the anticipated basis changes into account, called "anticipatory hedging" by Working (1962), are really hybrid operations--part hedging on price level and part speculation on basis (Working, 1962). Note that a hedger may "unwind" his hedge whenever the basis change is anticipated to be unfavorable and bear the costs of storage until time for the actual transaction.

### Spreading

A third type of market participant is the spreader. This person trades on the difference between futures prices at two different points in time, between related futures contracts, or between similar contracts on different exchanges. For example, if in July the futures price for 90-day TBills contract maturing in September is perceived as too low relative to the same contract due in December, a spreader would sell the December "expensive" contract and buy the September "cheap" contract. If, as he expects, the September price rises relative to the December price, he gains as his long position has larger profits (smaller losses) than his short position has losses (gains) if the prices move up (down).

To add some numbers, on July 1 let the September TBill price be 88.00 and the December price be 92.00, implying market values of \$970,000 and \$980,000 respectively. The spreader sells the December, buys the September, or he

buys the spread at -4.00. If at the end of July the September contract is at 90.00 and the December is at 93.00, he has profited because the spread has risen to -3.00. The gain from reversing the spread is 1.00, or \$2,500, calculated as follows:

gain on September =  $90.00 - 88.00 = 2.00$  or

$975,000 - 970,000 = \$5,000.$

loss on December =  $92.00 - 93.00 = 1.00$  or

$980,000 - 982,000 = \$-2,500.$

net gain =  $\$5,000 - 2,500 = \$2,500.$

As with hedging, the spreader trades on price relations, not on price levels. The key to a spreader's success is in predicting relative price changes. His trading strategy in interest rate trades such as the example above may be based on implied forward rates from term structure curves, knowledge of trends in economic factors or knowledge of the forward rates in the forward market. Spreaders are thought to bear less risk than speculators, and achieve smaller potential gains per spread. Note too that they pay more commissions since each simple spread involves four transactions.<sup>17,18</sup>

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<sup>17</sup>"Butterflies" or spreads of spreads require eight transactions in total and generally this type of trade is made only by traders on the exchange floor who pay low transactions costs.

<sup>18</sup>There are other types of spreads, such as between two contracts for different goods (e.g., a short in commercial paper against a short in TBills) undertaken when the spreader feels the price relation is out of line.

Market Mechanics

As noted above, futures trading is conducted only by members of the exchange and all trading is by public outcry during specified trading times. As trades are made, an observer makes the prices known by posting them on a quotation board. Instantaneously these prices are wired across this country and to several foreign cities.

When a person wishes to trade, he calls his broker who in turn relays the order to his firm's floor broker. The floor broker tries to execute the trade as it is stated in the order. Orders may be simple such as "sell two December TBills at market" meaning sell two contracts for December delivery of TBills quickly, at the best price the market will offer, or more complicated, stipulating the time of executive, or a combination of trades to be executed at certain price relations. The quality of the floor broker depends on his ability to execute orders at favorable prices. Trading is facilitated by a type of speculator called a scalper. The scalper seeks to buy on price dips caused by selling pressure and sell on price bulges caused by buying pressure. Typically a scalper holds an open position (long or short) in a contract for only a short time, and performs no analysis of underlying economic factors to guide his trading. A scalper engages in many transactions per day, trading on the smallest of price moves. The

liquidity of the market is dependent on scalpers; hedging costs are much lower in markets with active scalping which absorbs the short-term pressures of large orders, keeping bid-ask spreads low. Once the order is executed it is communicated verbally to the trader, and later in writing from his broker. Sometimes execution can be so rapid that a trader learns of execution within a minute of placing the order.

At the end of the trading session, member firms transmit all executed orders to the clearinghouse, the usually separate corporation that performs services much like the banking system's clearing operations. Each exchange has its own associated clearinghouse, and the members of the exchange are all either clearinghouse members or are affiliated with a clearing member. The clearinghouse becomes the "seller's buyer" and the "buyer's seller" for each transaction in the exchange, thereby facilitating reversal of positions.

When a buyer buys, a seller must sell. These two traders are acting for themselves or their clients. At the end of the day, however, the clearinghouse interposes itself between the traders, taking the long side of the seller's trade and the short side of the buyer's trade. Then to close a position, either the buyer or the seller merely reverses his original transaction in the market. That afternoon, the clearinghouse finds that it has offsetting positions for all traders who have closed out and merely

needs to settle their accounts for that day's price moves (all previous days' price moves having been settled as they occurred). For example, X buys 1 corn contract for \$2.75. Y is the seller. The next day X closes his position, not by locating Y and negotiating, but merely by entering a sell order in the market. Another trader takes up X's offsetting order to sell. Say the price is \$2.80. The clearinghouse was short to X's original long and long to Y's short. Now X closes out and the clearinghouse goes long to X, in the process losing \$.05 to X. But Y's position has declined \$.05, so the clearinghouse is even on X's and Y's trades (as well as everyone else's), has paid X off, and will continue carrying Y's position until he closes out.

At the maturity date of the contract, some traders will still have long or short open positions. The clearinghouse facilitates the delivery process by notifying shorts that they must deliver and assigning delivery to the oldest outstanding long positions on record. If disputes arise between shorts and longs over delivery, the clearing members for each side meet and resolve the dispute. Very few disputes are not settled in this way.

A final function served by the clearinghouse corporation is to guarantee performance of its members. All the financial assets of the members are pledged in the performance of any of its members. The clearinghouse is clearly central to the safe, efficient functioning of the



futures market, and the chief instrument by which the futures market provides the secondary market liquidity that makes it a valuable financial institution.<sup>19</sup>

### Special Features of Financial Futures

Treasury bonds and certain other financial futures have special delivery mechanics which should be noted. The contract grade on the CBOT is \$100,000 face value of a non-callable 8% coupon TBond with at least 15 years to maturity, or a callable 8% bond with at least 15 years to the call date. If a bond of better than contract grade is delivered, the deliverer receives a price premium, and if a lower grade is delivered, the buyer receives a discount from the futures price on settlement day. Premium and discounts are based on years to maturity and coupon rates. The TBill contract is simply \$1,000,000 face value of 90, 91, or 92 day TBills, with discounts for the two longer maturities.

Referring to the CBOT TBond contract, a short delivering a 10% TBond with 18 years to maturity would receive a premium. This premium is computed as a factor which reflects the price per dollar of the delivered bond at the 8% contract yield to maturity. For this bond the factor is 1.187. Thus if the futures price on settlement day is 94-16

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<sup>19</sup> See Powers (1973) and Sharpe (1978) for more detailed discussions of market mechanics.

(94 and 16/32%), the short invoices the long \$94,500 (1.187) = \$112,171.50 for \$100,000 face value of the 10%, 18 year TBonds.<sup>20</sup>

Another feature of financial futures, which is opposite to some of the agricultural futures, is the changing character of the actual commodity relative to the futures contract over the life of a hedge operation. The underlying interest rate instrument gains value as time passes, ceteris paribus, while some agricultural commodities decay (lose value) as time passes, ceteris paribus.

This chapter has presented the fundamentals of future trading and futures markets, with special reference to financial futures. Chapters 2 and 3 describe the important theoretical and existing empirical investigations of the spot price effects of futures trading, respectively. These first three chapters provide sufficient background for the presentation of the original work in this dissertation. The methodology and results are presented in Chapter 4. Chapter 5 contains the summary and conclusions of this study.

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<sup>20</sup>It should be noted first that this premium/discount feature is the same concept as in the agricultural futures contracts, and as in those contracts, the futures price will track the (possibly changing) cheapest delivery instrument contract as maturity draws near.

## CHAPTER 2 THEORETICAL ASPECTS OF THE PRICE EFFECTS OF FUTURES MARKETS

For futures trading to have any price effects on the related cash market it must impact on the decisions of demanders and suppliers of the cash good, since the cash price is the outcome of supply and demand decisions by handlers, producers and consumers of the good. Suppose that futures market participants were "merely speculators," whose activities consisted only of betting with one another on the outcome of a spot price at some future date. Suppose that the economic agents involved in one way or another with the actual commodity took no notice of the speculators' activities. Clearly, while someone may object to such futures markets as promoting gambling, there could be no objection based on ill effects in the actual commodity market, since there would be no effects.

Of course futures markets are not as described above. There are real effects associated with futures market trading because handlers, producers and users of commodities frequently use futures markets in at least two ways:

1. They take positions in futures contracts to hedge their actuals<sup>1</sup> positions based on the futures price. Of

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<sup>1</sup>Actual here means physical interaction with the good, either current or contemplated.

course they may also take speculative positions, but this part of their use of futures markets may be lumped in with pure speculators--persons with futures positions but no current or contemplated actuals positions.

2. They observe futures prices and hence these enter the information set that they use in making their decisions about their actuals positions. These two channels are not mutually exclusive; both may be operating in a given market at the same time.

This chapter will describe the theoretical arguments presented in the literature concerning price effects of futures trading in light of the above channels through which futures markets may operate. It will be convenient to discuss first the theories concerning futures trading in which there are beneficial effects on spot price volatility, and then the counter-argument showing potential negative effects.

### The Case for Stabilizing Futures Trading

The classical economic argument regarding the benefits of speculation may be traced back (at least) to J.S. Mill:

These dealers [speculators] naturally buying things when they are cheapest, and storing them up to be brought again into the market when the price has become unusually high; the tendency of their operations is to equalize price, or at least moderate its inequalities. The price of things are neither so much depressed at one time, nor so much raised at another, as they would be if speculators did not exist.  
(Mill, 1848, sections 4 and 5)

This beneficial impact of speculation on price stability rests on the assumption that speculators can foresee price movements well enough on average to move supplies into a more efficient intertemporal configuration. Before considering the counter-argument, it is necessary to find the implications of this theory for our discussion of futures trading.

Futures markets are distinguishable markets in several respects, all of which contribute to the facilitation of speculative activity by lowering transactions costs. First futures markets are highly public and competitive in organization. In fact these markets may approximate the ideal of being "perfectly competitive" as well as any market. Futures prices, volume of trade, and other important statistics are published often, and futures and spot price quotes are immediately available. Futures prices are determined by sellers and buyers of futures contracts in an open outcry forum in a centralized location. There are typically numerous traders on both sides of each contract, the largest group being speculators called scalpers and day traders, who with equal ease take either side of a contract depending on their forecast of very short-term price movements.<sup>2</sup> These traders provide a degree of "liquidity" to participants in futures markets that is not found in other

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<sup>2</sup>Note that one reason given for the demise of certain futures markets has been the lack of a large body of such traders.

marketing structures (Working, 1977). This allows buy and sell orders to be executed at very nearly the last recorded transaction price. Secondly, the standardization of the traded commodity contract relieves participants of the necessity of examining goods for differences in quality, quantity and location, and is of course fundamental to the difference between forward and futures trading. Third, actual brokerage fees are low (\$60 on a round trip TBill transaction at the CME). Fourth, speculators may trade on the futures market in accordance with their price predictions without the need to handle the physical commodity. The economies that are obtained by the separation of the handling function from the price prediction function offer definitely lower costs of speculation than if speculators had to store the good themselves, as in Mill's description of speculation. Lastly, transactions costs are low because capital requirements are smaller than in other forms of speculation, chiefly due to the clearinghouse procedure. The clearinghouse eliminates the possibility of default by a futures contract holder who is losing money. The clearinghouse is able to offer a guarantee of performance by forcing daily resettlement of gains or losses on participants' margin accounts, and because allowed daily price fluctuations are limited to prevent large negative margin account balances from developing. By these devices, only a small

performance bond, called margin, is required for traders to take positions, as opposed to the much larger capital which would be required to speculate by storing the physical good.

Hence, futures markets contribute to speculative activity by lowering the cost of speculation. But speculation in the sense described by Mill is not the same as the term speculation referring to futures markets. It is clear that in Mill's useage of the term, speculation "works" by the physical handling of the good, while in a futures market, pure speculators do not touch the good, nor would some of them be able to even recognize it. Mill's concept applied to a futures market requires that speculators affect the temporal allocation of supplies of storable commodities by providing actuals traders with the hedging opportunities described in the introductory chapter, and/or providing information about future spot prices.

Futures prices provide the handlers with the "price of storage" in Working's terminology, and so influence spot prices indirectly by influencing the storage decisions of handlers (Working, 1948). Assuming speculators' information is correct, the futures price will guide the stockholding that must be done over a crop year such that the harvest time price is higher and subsequent spot prices are lower than would be the case without futures markets. Hence the seasonal spot price fluctuations are mitigated by the activities of speculators. Note that there is a feedback from

handlers' storage decisions to the futures price. As crops are moved into storage, speculators lower their estimate of the future spot price and this provides a signal to handlers as to the storage decision of others.<sup>3</sup>

For commodities which are not carried over from one crop year to another, e.g. onions, futures markets can reduce the seasonal price fluctuation by providing more efficient regulation of flow from stocks by the establishment of an "equilibrium" spot price early in the storage season. This reduces the end-of-storage season spot price changes necessary to exhaust supplies prior to the next harvest. For commodity contracts that span the time period between planting season and harvest, futures prices also provide a guide to profits from production and thus influence future supplies through producer response, in a manner analagous to the storage response outlined above. The accuracy and efficiency of the futures price in these allocative roles is the central empirical question in the studies to be reviewed in the next chapter.

In summary, in order for futures market speculators to affect spot prices of storable goods, the handlers of the actual commodity must adjust their temporal allocation of supplies to the constellation of spot and futures prices.

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<sup>3</sup>This is not intended as a dynamic analysis of the feedback mechanism; speculators base their futures positions on their estimate of the future course of prices which takes the induced response of actuals handlers into account.



This aspect of futures trading, the separation of handling and production from price speculation, is one of the primary differences between futures market speculation and forward market speculation or the speculation described by Mill. As discussed above, it allows economies of specialization and may lead to better temporal allocation of supplies. However, there are elements of "speculation" in nearly all forms of hedging, and there is a two-way link between the futures price formation process of pure speculators and the inventory decisions of hedgers in futures markets for storable commodities.<sup>4</sup> It is not possible to distinguish hedgers, as the term is commonly used in futures markets, from speculators, as that term is commonly used in futures markets, in the concept of speculation which Mill described. Ultimately, hedgers perform the intertemporal allocation of supplies that is required to smooth prices over time, basing their decision on the constellation of spot and futures prices which are affected by speculators' futures positions.

This describes the mechanism by which futures trading works to reduce the spot price volatility over a storage season for storable commodities.<sup>5</sup> Several studies have been conducted to test whether this in fact is the case. These studies are reviewed in the next chapter.

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<sup>4</sup>Note that inventory is a broad concept here, referring to both storage of produced goods in final form, and storage of producible goods in the form of inputs to the production process.

<sup>5</sup>If storage continues to the next crop year, this mechanism is purported to stabilize year to year spot commodity prices by guiding the crop carryover from year to year.

Two key links in the mechanism described above have been left undiscussed. One of these links is the manner and the degree to which the information gathered by speculators is reflected in the futures price. The second link involves the quality of the information reflected in the futures price. The first question, the informational content of futures prices, has been investigated in several papers, notably Grossman (1970), Cox (1976) and Danthine (1978). Black (1971) has suggested that the major benefit of futures markets is in the price information they provide. We leave the discussion of the second link until later in the chapter when the case for destabilizing futures trading is presented and concentrate here on the papers by Grossman and Danthine. The paper by Grossman, an important work in several respects, is not as directly relevant or illuminating for the present study as is the paper by Danthine, which builds upon Grossman's work. Hence, a brief description of the Grossman paper is given first, followed by a more detailed review of Danthine (1978) which will highlight the potential for futures markets to be stabilizing or destabilizing, exactly paralleling the earlier work by Mill (1848) and Kaldor (1939).<sup>6</sup>

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<sup>6</sup>Kaldor presents the counter-argument to Mill's view of stabilizing speculation and his paper will be discussed later in this chapter.

Grossman examines several models with differing characteristics as to the nature of the uncertainty about future demand and supply and as to marketing institutions. His interest is in deriving the conditions under which information collected by some firms is disseminated by observable market prices in equilibrium. All firms fall into one of two groups, informed or uninformed firms. There are no speculators as such; all firms are producers of the good in period one and storers of the good in period two. Their single actuals decision involves how much of the period one output to store. In a model with only spot markets and uncertainty in both demand and output, a competitive equilibrium results where firms have different expectations as to the futures spot price, depending on whether the firm is knowledgeable or not about some existing information. Informed firms have exact knowledge of the random component of output and some unbiased information about the distribution of the random parameter in period two demand. Uninformed firms have some subjective probability distributions over the possible values of the two parameters. Firms that become knowledgeable have a better prediction of the futures spot price, and hence have higher expected profits from their storage decision.<sup>7</sup> The current spot price does not reveal all of the knowledgeable firms' information so these firms earn a return from their knowledge.

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<sup>7</sup>In Grossman's model all firms are risk-neutral and hence seek to maximize expected profits.

This result follows basically from the inability of one statistic, the current spot price, to reveal to the uninformed firms the two separate pieces of knowledge possessed by the informed firms.

The introduction of a futures market into the model changes this result. Grossman shows that with all firms risk-neutral,  $P_f = E[P_2 \mid \theta]$  where  $\theta$  is the information possessed by knowledgeable firms,  $P_f$  is the current futures price for delivery at time two, and  $E[P_2 \mid \theta]$  is the knowledgeable firms' conditional expectation of the period two spot price, at time one. That is, in this scenario all information is revealed in the equilibrium spot price and futures price, and uninformed firms make the same storage decisions and have the same expected profits as do informed firms.

This result depends critically on the assumption of identical, risk-neutral firms differing only in their information set. As Grossman shows, if the two classes of firms have different risk-aversion parameters which are known only by the firms possessing them, the introduction of a futures market will not eliminate the information asymmetry. Intuitively this occurs because the futures price will no longer reflect only the informed firms' information, but also their unknown risk-aversion parameter (Grossman, 1970, Theorem 7).<sup>8</sup> As in the situation with only spot

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<sup>8</sup>Note also that differing storage cost functions would cloud the information revealed by the futures price.

markets, there are too few statistics to reveal too many unknowns.

In this model, the volume of futures trading reflects the differences in information as well as the differences in risk attitudes. Futures trading takes place only between informed producers and uninformed producers. There are no pure speculators and, ignoring differences in risk attitudes, someone loses every time someone else gains on the futures market. This is in contrast to a situation with pure speculators where differences in initial positions can cause trading that is mutually beneficial, even when risk attitudes and expectations are identical.

Danthine presents a model with both pure speculators and producer/hedgers, where pure speculators have some information regarding the value of the uncertain parameter  $\tilde{\eta}$  in next period's demand function.

$$Q^d = D(p, \tilde{\eta}), \quad \frac{\partial D(p, \tilde{\eta})}{\partial p} < 0, \quad \frac{\partial D(p, \tilde{\eta})}{\partial \tilde{\eta}} > 0,$$

and  $g(\eta)$  is the probability density function. The output of each identical firm is  $q = q(x)$  where  $x$  is the quantity of input with unit price. This production function is shared by the  $N$  producers with  $\frac{\partial q}{\partial x} > 0$ ,  $\frac{\partial^2 q}{\partial x^2} < 0$ . Danthine's interest is in examining the role of futures markets as information markets and risk-transfer markets. All agents are risk-averse and seek to maximize their expected (strictly concave Von-Neuman-Morgenstein) utility function.

Let  $p^f$  represent the start of period 1 futures price for delivery at the start of period 2,  $f$  represent the number of unit futures contracts the producer sells, and  $\tilde{p}$  represent the (random) spot price at the start of period 2 when the crop is harvested. Then the producer's problem at period 1 is

$$(0) \max_{x, f} E[U((q-f)\tilde{p} + p^f f - x) \mid p^f], \text{ s.t. } q=q(x), x \geq 0$$

where locational and quality differences between the farmer's output and the futures contract specification are ignored. The expectation  $E$  is conditional on the only (relevant) information the farmer possesses at the start of period 1, the futures price.<sup>9</sup> It is clear that the futures price can impact on  $\tilde{p}$  by affecting input usage  $x$  and hence forthcoming output and by influencing the farmer's time 1 expectation of the forthcoming period 2 spot price.

Solving this problem requires consideration of first order conditions only since the utility function and production function are both concave. Letting

$$(q-f)\tilde{p} + p^f f - x = \tilde{y} \text{ the first order conditions are }^{10}$$

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<sup>9</sup>In this model there is no discussion of storage, but it is clear that the producer could be called a storer, and the storage cost function could be substituted for the production function, giving the model broader interpretation with no change in the results of interest.

<sup>10</sup>We ignore the possibility that  $x = 0$  for a producer since that would make him a pure speculator, a group to be considered next.

$$(1) \quad 0 = E[U_1(\tilde{y})\tilde{p} \mid p^f] q_1(x) - E[U_1(\tilde{y}) \mid p^f].$$

$$(2) \quad 0 = E[U_1(\tilde{y}) \mid p^f] p^f - E[U_1(\tilde{y})\tilde{p} \mid p^f].$$

Substitute for  $E[U_1(\tilde{y}) \mid p^f]$  from equation (2) into (1) to yield

$$(3) \quad p^f q_1(x) = 1.$$

This equation (3) gives  $x$  as a function of  $p^f$ ,

$$(4) \quad x = x(p^f).$$

with  $x_1(p^f) > 0$ . Examining  $\tilde{y}$  reveals it to be a function only of  $\tilde{p}$ ,  $f$ , and  $p^f$  by (4) and hence the expression in (2) defines an implicit function in only  $f$  and  $p^f$  which can be solved for  $f$

$$(5) \quad f = f(p^f).$$

As Danthine notes, the expression  $x = x(p^f)$  tells us that the producer takes only the futures price into account in his production decision and then acts as a speculator if there is divergence between  $q^* = q(x(p^f))$  and  $f^* = f(p^f)$ ,  $q^*$  and  $f^*$  the optimal output and futures position.<sup>11</sup> If  $q^* > f^*$  then the producer speculates in his actuals position and if  $q^* < f^*$  he is speculating in his futures position. Total supply is given by

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<sup>11</sup>See Feder, Just, Schmitz (1980) for a similar model with this result.

$$(6) \quad Q^S = Nq^* = Nq(x(p^f)).$$

Consider the optimization problem of each of  $n$  identical speculators. Suppose speculator  $i$  has some information  $v_i$  regarding the value of  $\tilde{\eta}$  such that  $\eta = v_i + w_i$  with  $w_i \sim N(0, \sigma_w^2)$  and the  $w_i$  are i.i.d. That is, speculators are assumed to collect unbiased information regarding the future demand and trade futures contracts on the basis of this information to

$$(7) \quad \max_{b_i} \int_{-\infty}^{\infty} W[(p(p^f, \tilde{\eta}) - p^f)b_i] g(\eta | v_i, p^f) d\eta$$

where  $b_i$  is the number of unit futures contracts bought by speculator  $i$  and  $g(\eta | v_i, p^f)$  is the conditional density for  $\eta$ .  $W$  is the strictly concave Von-Neuman-Morgenstern utility function shared by all speculators.

We are justified in writing  $\tilde{p} = p(p^f, \tilde{\eta})$  in (7) by (6) above, and writing  $g(\eta | v_i, p^f)$  reflects a tatonnement process wherein all traders make their final decisions based on the market clearing  $p^f$ . Again, any divergence that could occur between producers' output and the contract specification is ignored in (8) so the closing futures price equals the period 2 spot price.

The first order condition yields

$$(8) \quad \int W_1[(p(p^f, \tilde{\eta}) - p^f)b_i][p(p^f, \tilde{\eta}) - p^f] \cdot g(\eta | v_i, p^f) d\eta = 0.$$

This integration yields an implicit function in  $b_i$ ,  $v_i$  and  $p^f$ ; hence,



$$(9) \quad b_i = b(p^f, v_i),$$

where by the assumption of identical speculators  $b(p^f, v_i)$  is the common demand function for futures contracts.

Requiring the futures market to clear at price  $p^f$  we have from (5) and (9):

$$(10) \quad Nf(p^f) - \sum_{i=1}^n b(p^f, v_i) = 0.$$

Assume that both the supply and demand for contracts are monotonic in  $p^f$  ( $f_1 > 0$ ,  $b_1 < 0$ ) to obtain:

$$(11) \quad p^f = h(v_1, v_2, \dots, v_n) = h(V),$$

where  $V$  is the row vector  $(v_1, v_2, \dots, v_n)$  of speculators' individual information.

Equation (11) gives the futures price as a function of the  $\{v_i\}$  or of the expectation of the parameter  $\tilde{\eta}$ . The role of the futures price in information dissemination is clear. Some reflection of all individual pieces of information  $v_i$  are in  $p^f$  and producers and speculators both condition their expectation of the future spot price on the statistic  $p^f$ . The futures price thus affects production and speculation decisions. The final equilibrium consists of  $p^f$  and the functions  $h(V)$ ,  $b(p^f, v_i)$ ,  $f(p^f)$  such that producers and speculators have maximized their expected utilities in equations (0) and (7) and the futures market clears equation (10).

The futures price  $p^f = h(V)$  shows the potential for information to be transmitted from speculators (information specialists) to hedgers, who in turn base their production (and/or storage) decisions on this price,  $q = q(x(p^f))$ . The hedging function  $f = f(p^f)$  shows the potential for risk-allocation through futures markets. This is a complete model of the futures market/spot market interaction.

Although the equilibrium functions define and close the model, Danthine provides a simple example which is useful for understanding further the role of futures markets and the potential for stabilizing or destabilizing effects on spot price. Let  $q(x) = \alpha x^{\frac{1}{2}}$  with  $\alpha > 0$ , be the production function and  $D(p, \tilde{\eta}) = a - cp + \tilde{\eta}$  with  $a, c > 0$ ,  $\eta \sim N(0, \sigma_\eta^2)$  be the demand function at time 2. Then (3) implies  $p^f \cdot \alpha/2 \cdot x^{-\frac{1}{2}} = 1$  or since  $q(x) = \alpha x^{\frac{1}{2}}$ ,  $q = p^f \cdot (\frac{\alpha^2}{2})$ . Solve  $Nq = D(p, \tilde{\eta})$  to yield the equilibrium spot price at time 2:

$$(12) \quad \tilde{p} = a/c - N \frac{\alpha^2}{2c} p^f + 1/c \tilde{\eta}.$$

Now we can write the profit for a producer as

$$(13) \quad \tilde{y} = \left( \frac{\alpha^2}{2} p^f - f \right) \left( a/c - N \frac{\alpha^2}{2c} p^f + 1/c \tilde{\eta} \right) + p^f f - \frac{\alpha^2}{4} (p^f)^2,$$

and the profits for a speculator as

$$(14) \quad \tilde{z}_i = \left( a/c - N \frac{\alpha^2}{2c} p^f + 1/c \tilde{\eta} - p^f \right) b_i.$$

Let  $U(y) = -e^{-2\theta y}$  and  $W(z) = -e^{-2\varnothing z}$  be the farmers' and speculators' utility functions. Then  $2\theta$  and  $2\varnothing$  are the respective Pratt-Arrow measures of (constant) risk-aversion, and each type of agent seeks to maximize<sup>12</sup>

$$\hat{U}(\tilde{y}) = E(\tilde{y}) - \theta \text{var}(\tilde{y})$$

$$\hat{W}(\tilde{z}) = E(\tilde{z}) - \varnothing \text{var}(\tilde{z}).$$

By the first order conditions for maximization and the definition of  $\tilde{y}$  in equation (13) and  $\tilde{z}$  in equation (14) above,

$$(15) \quad \bar{p} = \frac{\alpha^2}{2} p^f - \frac{c^2}{2\theta \text{var}(\tilde{\eta}|p^f)} [E(\tilde{p} | p^f) - p^f] \text{ and}$$

$$(16) \quad b_i = \frac{c^2}{2\varnothing \text{var}(\tilde{\eta}|v_i, p^f)} [E(\tilde{p}|v_i, p^f) - p^f].$$

The market clearing condition (10) can be imposed on (15) and (16) to yield the equilibrium futures price:<sup>13</sup>

$$(17) \quad p^f = \frac{1}{M} \left[ \frac{Nc^2}{2\theta \text{var}(\tilde{\eta}|p^f)} [a/c + 1/c E(\tilde{\eta}|p^f)] + \frac{c^2}{2\varnothing \text{var}(\tilde{\eta}|p^f, v)} (na/c + 1/c \sum_{i=1}^n E(\tilde{\eta}|v_i, p^f)) \right],$$

<sup>12</sup>This requires that  $\tilde{y}$  and  $\tilde{z}$  are normally distributed, which they are since both are linear in  $\tilde{p}$  which is normally distributed.

<sup>13</sup>Recall that  $v_i$  and  $v_j$  are identically and independently distributed with  $\sigma_w^2$  constant across speculators, so  $\text{var}(\tilde{\eta}|p^f, v_i) = \text{var}(\tilde{\eta}|p^f, v_j)$  for all  $i, j$ . Let  $\text{var}(\tilde{\eta}|p^f, v) = \text{var}(\tilde{\eta}|p^f, v)$ .

$$\text{where } M = \frac{Nc^2(1 + N\frac{\alpha^2}{2c})}{2\theta \text{var}(\tilde{\eta}|p^f)} + \frac{N\alpha^2}{2} + \frac{nc^2(1 + N\frac{\alpha^2}{2c})}{2\theta \text{var}(\tilde{\eta}|p^f, v)}.$$

As (17) shows, some information passes from speculators to producers, and among speculators, by way of the futures price quotation through the terms  $\text{var}(\tilde{\eta}|p^f, v)$  and

$$1/c \sum_{i=1}^n E(\tilde{\eta}|v_i, p^f). \text{ In a two-way process discussed above}$$

(page 14), this information feeds back on the production decision of farmers,  $q = q(x(p^f))$ , then back again into the expected futures spot price, etc. The question is how well the speculators' information is disseminated by the futures price. If the futures price reveals some of the relevant information, and given the assumption that speculators' information is unbiased, then the futures market is a stabilizing force in the spot market.

Suppose that the futures price reveals all the speculators' information (i.e., is a sufficient statistic for  $\{v_i\}$ ), then  $E(\tilde{\eta}|p^f) = E(\tilde{\eta}|v_i, p^f)$ . Farmers and speculators have the same expected value of  $\tilde{\eta}$ . By the assumption of normally distributed, independent  $v_i$ 's with a common mean and variance, a sufficient statistic for  $\{v_i\}$  is  $\sum_i v_i$ . Hence (DeGroot, 1970, Theorem 1):

$$E(\tilde{\eta}|p^f) = E(\tilde{\eta}|\sum v_i) = \frac{\sigma_{\tilde{\eta}}^2}{n\sigma_{\tilde{\eta}}^2 + \sigma_w^2 \sum v_i} \text{ and}$$

$$\text{var } (\tilde{\eta}|p^f) = \text{var } (\tilde{\eta}|v_i, p^f) = \text{var } (\tilde{\eta}|\Sigma v_i) = \frac{\sigma_w^2 \sigma_\eta^2}{n\sigma_\eta^2 + \sigma_w^2}.$$

Substituting these expressions into (17) yields the following expression for  $p^f$ :

$$(18) \quad p^f = A + B\Sigma v_i \quad \text{where}$$

$$A = \frac{(N\emptyset + n\theta) a/c}{(N\emptyset + n\theta) (N \frac{\alpha^2}{2c} + 1) + N\alpha^2\theta\emptyset \frac{1}{c^2} \frac{\sigma_w^2 \sigma_\eta^2}{n\sigma_\eta^2 + \sigma_w^2}}$$

$$B = 1/c \frac{\sigma_\eta^2}{n\sigma_\eta^2 + \sigma_w^2} \frac{Ac}{a}.$$

This is equation (11) for the example problem chosen.

Note that here, as in Grossman's paper, the futures price is invertible in the information set of the informed group only if the preferences of all individuals are group-determined and the stochastic nature of the model is as postulated. If there are differences in speculators' risk-aversion or their information quality (so that  $\sigma_{wi}^2 \neq \sigma_{wj}^2$ ) the futures price alone will not reflect all of the information. For example, if  $\sigma_{wi}^2 < \sigma_{wj}^2$ , it is desirable to be able to separate  $v_i$  from  $v_j$ , but one statistic, the futures price, cannot reveal these separate pieces of information.

In this parametric example it is interesting to note that the variance of the spot price with futures trading is less than without futures trading if  $\sigma_\eta^2 \geq \sigma_w^2/n$ , that is if the variance of the spot price given  $\Sigma v_i$  is less than

the unconditional variance (Danthine, 1978).<sup>14</sup> This somewhat obvious result highlights two facts of importance:

1. If speculators are not collecting valuable information, they do not reduce the spot price variance, although they still serve an economic function by providing for risk transferring.

2. More speculators with (unbiased) information are generally helpful; although as noted above, if there are differences in their reliability such that  $\sigma^2 w_i \neq \sigma^2 w_j$ , this may not be true.

### Destabilizing Futures Markets

This detailed review of Danthine's work highlights the nature of the disagreement over the stabilizing effect of futures trading. In the papers by both Grossman and Danthine (as in Mill's and Working's models), speculators are presumed to have accurate information of some content and producers (storers) use the futures price as a statistic revealing that information as well as a means of hedging against adverse movements in the spot price.

To quote from one of Working's papers,

In the absence of futures trading the potential holders of stocks are, in the main, only growers and dealers who have storage facilities. In the presence of futures trading, a dealer with stocks in storage may hedge them, and when he does so, the buyer of the hedging contracts becomes, from the standpoint of price effect, the holder of those

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<sup>14</sup>Note that this condition requires the futures price to reveal all the speculators' information ( $\Sigma v_i$ ), which it does in the example.

stocks. Hedging thus causes holders of futures contracts to exert influence on the spot price. [This view of futures trading shows] that the influence of futures trading on spot prices must depend roughly on the proportion of total stocks that is hedged. . . . (Working, 1960, pg. 6)<sup>15</sup>

There is in this statement the clear possibility that futures trading may be destabilizing or stabilizing, depending upon the accuracy of the signal provided by the futures price as to desirability of storage. Suppose there is optimism among speculators with respect to spot prices in the future. There would be increased demand for futures contracts at the current futures price, which would then rise. Actuals handlers would see an increased return from storage and so increase their stockholdings. (Depending on their risk preferences and other information, they may choose to hedge all or part of their increased stocks.) If speculators turn out to have been correct, the increased stockholding will help stabilize the spot price by bringing supplies back onto the market at the later (higher price) period. This would then have been exactly the type of speculation Mill envisioned. If, however, speculators were wrong, the increased stocks would come back onto the market at a time of depressed spot price, having been shifted from the earlier period. Spot price would then be destabilized and the inefficient temporal allocation in stocks

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<sup>15</sup>Of course this statement needs to be broader, including any unhedged stockholding that is encouraged by the futures price quotation. Working recognized this; see Working (1953b).

would have resulted in a social loss. The key is the accuracy or inaccuracy of the information contained in the futures price.

The standard argument in favor of accurate information coming from speculators is simple: speculators who trade on inaccurate information will lose money and be forced out of the market--only successful speculators will remain and they do so only by being correctly informed as to future spot market conditions (Kaldor, 1939). Hence futures markets tend to stabilize spot prices.

However, this argument may not hold.<sup>16</sup> There are two important and related elements that need examining:

1. Losses by poor speculators lead to the survival at any time of only successful (informed) speculators.
2. Speculation that generates profits is only related to future spot markets conditions and so stabilizes spot prices.

These two elements may both be false. As Kaldor suggested:

. . . the losses of a floating population of unsuccessful speculators will be sufficient to maintain permanently a small body of successful speculators; and the existence of this body of successful speculators will be sufficient attraction to secure a permanent supply of this floating population. (Kaldor, 1939, pg. 2).

Hence at any and every time there may be a large population

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<sup>16</sup>Some writers seem to claim that it does hold. See Friedman (1953) pg. 175, and his note further down the same page.



of uninformed or misinformed speculators, and speculators as a group may continue to show losses indefinitely. Further, it may be possible for successful speculation to involve forecasting the expectations of other speculators (the uninformed), and not the fundamental economic conditions in the future spot market. Kaldor states: "So long as they are numerous, they need not prove successful in forecasting events outside; they can live on each other" (Kaldor, 1939, pg. 2). Farrell has attempted to derive the conditions under which profitable speculation necessarily reduces spot price variability. He was unsuccessful at finding a set of robust conditions, concluding that the proposition "is too strong to hold with any generality" (Farrell, 1966, pg. 192). It is possible then for futures markets to destabilize spot prices by providing inaccurate signals as to future spot market conditions. There appears no logical grounds on which to reject this possibility so the question must be examined by an empirical investigation.

It is useful to summarize the arguments presented thus far as to the price effects of futures trading. Futures trading encourages speculation (and hedging) because it allows traders to take positions with very low transactions costs. These low costs are due to (1) the public and competitive nature of the markets' organization, (2) the standardization of the contract, (3) the clearinghouse mechanism which reduces capital requirements and the risk of default. The low transactions costs allow trading to

take place on the basis of small differences in traders' information sets and so encourages the gathering of information. The separation of the handling of goods from information-seeking and risk-bearing in futures markets allows specialization in each area and hence could improve the performance of both handlers and speculators. The wide dissemination of direct market information by exchanges and brokerage houses, and most importantly the information contained in the futures price itself, could have a stabilizing effect on the spot price by improving the intertemporal stockholding decisions of handlers of the good.

The possibility exists that futures trading may destabilize spot prices. Essentially this would occur if the futures market provided the "wrong" price signal to handlers. That is, if futures trading encourages speculation by ill-informed traders (who would show losses), the intertemporal constellation of prices could encourage handlers to make spot market decisions which destabilized spot prices. It may be that such a situation could not persist indefinitely. Studies have been conducted on the profits of speculators but since these studies do not provide direct evidence on the question at hand they are not discussed.<sup>17</sup>

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<sup>17</sup> See Rockwell (1967) and Houthakker (1959). Basically, there is no necessary connection between speculative profits and stabilizing futures trading so these studies do not provide the evidence sought here.

### Non-Storable Commodities

The theoretical arguments presented above did not expressly consider futures trading in a non-storable commodity. The question arises: What are the effects of futures trading on non-storable commodities?

Again, futures trading is unique because it is so inexpensive to trade, particularly for pure speculators, vis-a-vis other forms of speculation. By encouraging speculation futures trading can increase the amount of information coming into the market, and the information is widely disseminated by the exchanges and brokerage houses. This information may lead to more efficient decision-making by participants in the actuals markets by providing better forecasts of future spot market conditions. There is then the potential for reduction in the variance of the random component of spot price changes with more of the price change becoming "predictable" from the broader information set. On the other hand, incorrect information can increase the volatility of the spot price. For non-storable commodities the information aspect of futures trading is most important.

### Special Features of Treasury Instrument Futures

All of the arguments presented so far have concentrated on the supply side of the spot market. However, some markets may be more strongly influenced on the demand side by a futures market. Consider the effects of a futures market in a non-storable good such as Treasury Bills.

Hedgers in this market are long hedgers--those persons with an expected future demand for TBills who would be hurt by a rise in price (decline in yield).<sup>18</sup> For these hedgers, the effects of a futures market hedge is to compensate them for changes in the spot prices of TBills that may occur. The term "compensate" here is used exactly as in demand theory. If a person hedges his future desire for TBills by purchasing TBill futures, gains (losses) in the actuals position are, to some extent, offset by losses (gains) in the futures position. But of course the future spot market transaction may be of any size, depending on the spot price at the time, hence only part of the loss or gain on the futures transaction applies to the subsequent spot market transaction and the rest is spread over the trader's other purchases. Spot price increases are compensated by an increase in income from the futures position gain and spot price decreases are compensated at a decrease in income from the futures position loss.

Assume that the spot market demand curves with and without a futures market hedge can be described as linear in quantity. As in standard demand theory the compensated demand curve is steeper than the Marshallian demand curve. If the two spot demand curves cross at the expected spot price and the supply curve is taken as vertical with a random shift parameter,  $Q_s = \bar{S} + \tilde{\epsilon}$ , then the situation is

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<sup>18</sup> Ignoring cross-hedgers who may use the TBill market to hedge future planned borrowing in other markets.

described in Figure 1.<sup>19</sup> As can be seen, any given random shock  $\varepsilon$  will result in a larger random shock to the spot price along the demand curve with hedging in the futures market. Let the equation of this demand curve be  $P_1 = a_1 - b_1Q$  and let the equation of the demand curve without futures market be  $P_2 = a_2 - b_2Q$ . Then  $V(P_1) > V(P_2)$  since  $b_1 > b_2$  and  $V(Q_s)$  is presumed invariant to the existence of a futures market.

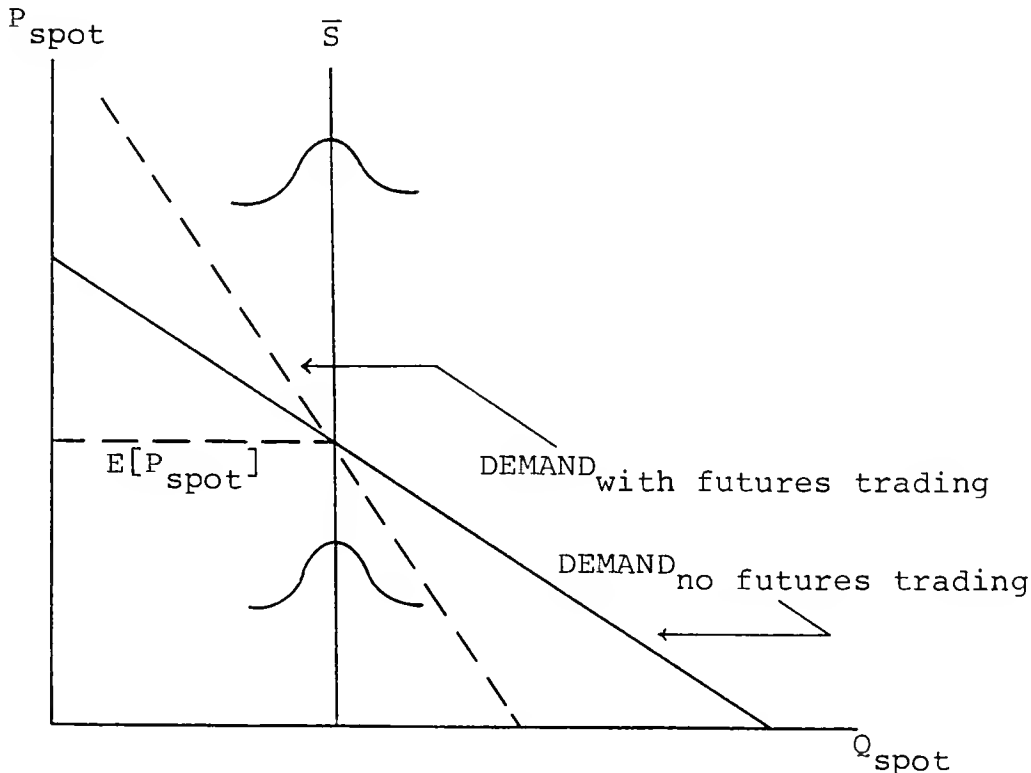


FIGURE 1  
SPOT PRICE VOLATILITY WITH AND  
WITHOUT TBILL FUTURES

<sup>19</sup> Since the good is non-storable this is a reasonable formulation for a supply function if the production decision must be made before the price is revealed. For TBills we may further suppose very little "producer response" to the information contained in the future price, at least as a first approximation.

Of course, this effect operates only to the extent that hedging is conducted on uncommitted forward demand for the spot good. If long hedging only occurs when the hedger has a commitment to purchase (for resale perhaps) a certain amount of the good, and will purchase only that amount, the offsetting gain or loss is totally reflected in the net price paid for the predetermined amount of the good purchased. Note further that this does not negate the earlier comments about the potential benefits of futures trading due to information. The increased information may still lower the variance of the unpredictable changes in spot price by reducing the conditional variance of the random shock  $\varepsilon$ .

One last note on the theoretical papers concerning the price effects of futures trading. Telser and Higinbotham (1977) described futures trading as a sorting of trades with respect to time. That is, futures markets reduce the heterogeneity of the group of traders in each time dimensioned market. They state that this effect may reduce the dispersion of the distribution of spot market price, but provide no compelling reasons as to why this will occur. It seems as reasonable to expect just the opposite result since a homogeneous group of traders might generate a price that is less resilient to changes in underlying market conditions than would a more heterogeneous group.

This concludes the review of the theoretical investigations into the spot price effects of futures trading.

The next chapter provides a review of the more noteworthy empirical studies on this question. These two chapters provide the necessary background against which to present the original work performed in this dissertation.

### CHAPTER 3

#### REVIEW OF THE EMPIRICAL INVESTIGATIONS OF THE PRICE EFFECTS OF FUTURES TRADING

In addition to the theoretical research into the price effects of futures trading, several empirical studies have been conducted to test for the influence of futures trading on cash prices. Several of these studies, for example, Working (1960), Gray (1963), Johnson (1973), Emerson and Tomek (1969) and Hieronymus (1960) reviewed here, have been concerned with the onion and potato futures markets. These markets have come under attack for causing price fluctuations so severe as to warrant their congressional prohibition. Onion futures trading was outlawed in 1958, and the potato futures market has been investigated several times.<sup>1</sup> Both of these goods are seasonally produced, storable commodities.

Other studies such as Powers (1970) and Taylor and Leuthold (1974) are concerned with continuously produced, non-storable commodities. A third group of empirical studies is from the interest rate futures markets. The three reviewed here, Froeweiss (1978), Gardner (1980) and

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<sup>1</sup> Onion futures are prohibited by Public Law 85-839, August 28, 1958, 72 Stat. 1013. The 85th, 89th and 92nd Congresses convened hearings on potato futures.



Figlewski (1981), represent the existing empirical research into the effects of futures trading on spot prices in the interest rate futures area. For the most part these interest rate futures studies suffer from failure to account for their incomplete specification of the determinants of cash prices. Failure to "hold other things constant" lessens the confidence one can have in the results of the studies.

The empirical studies discussed in this chapter are representative of the work that has been done in this area and provide a sufficiently complete background for appreciating the original work to be performed in this dissertation. They will be presented in three groups: storable commodities, non-storable commodities, and interest rate futures markets.

### Storable Commodities

Onion futures trading was banned in 1958, after a period of twelve years during which futures trading occurred on the CME. Onion futures trading is important to study because there are data from no-futures periods surrounding a period with futures. This allows a better possibility of controlling for other variables in analyzing the price effects of futures trading. Holbrook Working (1960) conducted an extensive study of this market and concluded, contrary to the Congressional findings, that futures trading in onions did not increase the variation in spot onion prices.

Working looked at two measures of spot price volatility, the average seasonal variability over the storage season, about September to March, and the intra-seasonal variability of prices. Working separates the period 1930/31 - 1957/58 into three subperiods: 1930/31-1940/41, a period of no-futures trading, 1946/47-1948/49 and 1958/59, a period of little hedging, and 1949/50-1957/58, a period of significant hedging of stocks.<sup>2</sup> This separation reflects the theoretical consideration that futures market speculation affects spot prices through the hedging behavior of holders of stocks.

The data reveal that the average seasonal price range from September to March is smallest during the period of significant hedging use of the futures market, while the two other periods of no-futures market and of little hedging show larger average cash price variation.<sup>3</sup> The Michigan prices show this pattern more strikingly as the Michigan market is the most likely hedging market on the CME due to Michigan's central location in the onion producing geography. Comparing yearly total price ranges, the data show that the years of significant hedging have consistently smaller price variation.

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<sup>2</sup>"Significant" hedging is approximately 15-20 percent of estimated onion stocks held at the peak of the storage season.

<sup>3</sup>Working used two different price series: U.S. average prices to growers and prices to Western Michigan growers. The two series show similar characteristics over the three periods.

The end of storage price changes occur in February to March and have historically been of relatively great magnitude. This is because new crop onions are superior to old crop onions so there is no carryover from one storage season to the next harvest. Again the data show that years with substantial hedging tended to have smaller price ranges February to March than years of little or no hedging. Comparison of month-by-month cash price ranges in the three periods shows that the end of storage price adjustment, necessary to exhaust old crop supplies prior to the new harvest, moved back in time to January in the period of hedging from February or March during periods of no hedging. Since the end of storage price adjustment regulates the demand flow out of the stock of stored onions, the early adjustment during the periods of hedging use of futures markets allowed a smaller price adjustment to exhaust stored onions before the harvest.

In summary, this study suggests that volatility of the cash onion market did not increase due to the introduction of futures trading. Rather, when futures markets were used for hedging purposes, cash price variations, measured several ways, seemed to be lower, contrary to the findings of Congress which passed the law banning futures trading in onions.

Gray (1963) and Johnson (1973) provided updates of part of the analysis performed by Working on the cash onion

market. Gray found that the period 1958-1962 showed a return to the type of average seasonal price variation experienced before futures trading in onions became established. Since futures trading was abolished in 1958, this evidence indicates that the decreased cash price variation from 1949-1958 was all the more likely to have been a result of futures trading, and not due to other factors that may have been ignored.

Johnson updates Gray's paper with data from 1962-1968. He finds that this no-futures period has an even smaller seasonal price range than Working's period of substantial hedging. Other analysis of weekly and monthly price ranges show that, except for the year 1958, price variations have been about the same in the period since the ban on futures trading (1959-1968) as in the period of significant hedging (1949-1957).<sup>4</sup> His conclusion is that futures trading had no effect on cash price variations.

In an early paper concerned with the price effects of futures trading, Hieronymus (1960) found that futures trading in onions did not increase the fluctuations in the cash prices of onions. As did other researchers, e.g. Working (1960) and Gray (1963), Hieronymus separated spot price series on onions into periods of time during which there were different amounts of futures trading. His result

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<sup>4</sup>If the year 1931 is also omitted, weekly cash price variation over the storage season from 1930-1968 has been strikingly similar year by year.

on the seasonal variation in onion prices agrees with Working and Gray--the period of highest futures activity had the lowest seasonal price variation. Other results in his paper from regression equations modeling short-term price movements, show also that futures trading does not increase cash market volatility in onions.

### Non-Storable Commodities

Much of the empirical work done on the question of price effects of futures trading relates to seasonally produced, storable commodities. Powers (1970) suggests that the results of these studies may not be valid for non-storable, continuously produced goods and seeks to test this on cash price data for live cattle and pork bellies for four years prior to and four years during futures trading in each commodity. He views variations in cash prices as composed of systematic and random components, which are uncorrelated by definition. Stating that futures trading in these types of goods may affect the random but not the systematic components of variations in cash price, he employs Tintner's "Variate Difference Method" (1940) to separate the two components. His tests then require comparing the estimated variance of the random element in price for the two four year periods.

Note that Powers' separation of the components of variations in cash price allows us to assign positive or negative social value to the price effects of futures trading. The systematic component arises from variations

in the underlying fundamental determinants of supply and demand for the good. The random component is noise or a random disturbance of price away from its equilibrium value. Thus a decrease in the variance of the random element is socially beneficial, while an increase is socially harmful, leading to resource misallocation.

Power's results show that for both live cattle and pork bellies the estimated variances of the random component were significantly lower in the period with futures trading. These results hold when each of the four year periods was split into two year subperiods. All of the estimated variances from the futures trading periods were significantly lower than from the corresponding pre-futures periods.

Powers argues that prices are more reflective of systematic (fundamental economic) factors in the futures trading period because of the improved information flow to market participants in this period. He claims that the only significant changes in market conditions between the two time periods for these goods was the opening of futures trading and hence futures trading is responsible for the reduction in the random variation of cash prices he observed.

Taylor and Leuthold (1974) analyze annual, monthly, and weekly variability in cash cattle prices for an eight year period before and an eight year period after the initiation of futures trading in live cattle. This commodity is not stored, in the usual sense, for any significant time, and is continuously produced. Hence futures trading

does not impact through the hedging of stored commodity in this market, but may affect the cash market through the producer-response mechanism described by Danthine (1978) and through the information-generating aspect of futures trading.

The authors argue that the initiation of futures trading was the most dramatic change in livestock marketing over the sixteen year test period. The results of their tests will then be directly attributed to futures trading.

Calculation of the annual average cash price variance around the eight year average price revealed no difference in annual variability between the two periods. Calculation of monthly variability in cash prices showed the futures trading period to be significantly less variable than the pre-futures trading period and a similar result appears from calculation of the average monthly coefficient of variation for the two periods. The data for weekly variance and coefficient of variation also showed this pattern.

They conclude that the cash live cattle market has been less volatile since the initiation of futures trading. Their explanation for this phenomenon runs (loosely) in terms of the increased information, reduced transaction costs, and reduced marketing costs that they feel are the results of futures trading in a non-storable commodity.

Cox (1976) focuses on the information-generating aspect of futures trading. He develops a model based on the Efficient Markets Hypothesis which leads him to

investigate the autoregressive structure of spot commodity prices in periods with and without futures trading. His hypothesis is that futures trading, by providing more information to more traders, will reduce the absolute size of the coefficients  $b_j$  in the regression equation:

$$P_t = b_0 + \sum_{j=1}^n b_j P_{t-j} + u_t,$$

where  $P_t$  is the current spot price,  $P_{t-j}$  is the  $j$ -periods past spot price, and  $u_t$  is the random disturbance term. A reduction in the absolute value of the  $b_j$ 's is indicative of more efficient spot price formation, with more of the available information being reflected in the spot price at each time  $t$ . Further, if this in fact is true, mechanical trading rules based on past price behavior will be less profitable as the  $b_j$ 's approach zero.

The commodities Cox tests are onions, potatoes, pork bellies, hogs, cattle and frozen concentrated orange juice. Generally, the results are as hypothesized: for onions, orange juice, hogs, pork bellies the test  $b_2 = b_3 = \dots b_n = 0$  is rejected for the no-futures periods and not rejected for the futures trading period, while one coefficient,  $b_2$ , remains significantly different from zero for cattle and potatoes with futures trading.

Cox also tests for changes in the estimated standard error of the regressions period. For all the tested commodities only the onion market fails to show a decrease in the estimated standard error, divided by the average spot



price to help control for overall price level changes, when futures trading occurs versus the no-futures period. Cox also tests a simple trading rule based on price prediction from past price behavior. Ignoring transactions costs, the period with futures trading shows lower average returns to the rule across the commodities and higher variances of returns than the no-futures period. Cox concludes that futures trading has not destabilized spot price in these commodities and has provided "more accurate signals for resource allocation" than when there is no futures market (Cox, 1976, pg. 1235).

#### Interest Rate Futures

GNMA futures began trading on October 20, 1975 on the Chicago Board of Trade. Two papers have been written concerning the effects of this market on spot GNMA prices. The first paper to appear was by Kenneth Froeweiss (1978) in which he argued that futures trading had not destabilized the spot GNMA market. The second paper, by Stephen Figlewski, concluded the opposite.

Froeweiss used weekly GNMA prices from two time periods, May 30, 1973 - October 15, 1975 and October 22, 1975 - December 28, 1977, to test the hypothesis that futures trading increased spot price volatility. He estimated a regression equation of weekly percentage changes in GNMA spot prices on weekly percentage changes in ten-year U.S. Government bond prices. The rationale for this regression

equation is that the ten-year government bond price changes proxy changes in general bond market conditions, excepting the influence of the new futures market. Hence any changes in the regression relationship in the two periods is attributable to the futures market. The results show no difference in the estimated coefficients of government bond price changes in the two periods. Moreover, the estimated standard error of the regression was smaller in the futures trading period than in the earlier period. Froeweiss uses this evidence to argue that futures trading has not made the GNMA's spot market more volatile.

There are some statistical difficulties with the method used to obtain these results. First, it is not at all clear that a change in the slope coefficient has anything to do with the spot price volatility effects of futures trading. No conclusion could be drawn from a rise or a fall in this coefficient about the destabilizing effects of futures trading without a considerably more complete model of GNMA spot price determination, and an explicit relationship of GNMA and ten-year government bond prices. Secondly, and more importantly, the simple regression model used has biased (and likely inconsistent) estimated standard error of the regression, and it is not obvious what the estimated slope coefficient and its standard error represent. This may be seen by considering a simple one-factor returns generating model (e.g., the CAPM).<sup>5</sup>

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<sup>5</sup>The same result would hold for a multi-factor returns-generating mechanism.

$$TYGB = \alpha + X\beta_{TYGB} + \varepsilon \text{ or } X = \frac{TYGB - \varepsilon - \alpha}{\beta_{TYGB}}$$

$$GNMA = \alpha + X\beta_{GNMA} + \eta$$

$$= TYGB \frac{\beta_{GNMA}}{\beta_{TYGB}} + \alpha(1 - \frac{\beta_{GNMA}}{\beta_{TYGB}}) + (\eta - \varepsilon \frac{\beta_{GNMA}}{\beta_{TYGB}})$$

where TYGB = ten-year government bond return over the week interval.

GNMA = GNMA return over the week interval.

X = the factor return premium (e.g., the market return premium).

$\varepsilon, \eta$  = random disturbance terms, necessarily uncorrelated.

$\alpha$  = return on the zero-beta asset.

$\beta_{TYGB}, \beta_{GNMA}$  = the response coefficients of the two instruments to the single factor.

Froeweiss' regression equation is then interpreted as a proxy variable approach, with X proxied by TYGB:  
 $GNMA = TYGB\gamma + \mu$ . An OLS estimation procedure applied to this equation will yield  $\hat{\gamma}_{OLS}$  as a biased estimator of  $\frac{\beta_{GNMA}}{\beta_{TYGB}}$ , and  $\frac{1}{n-2} u'u$  as a biased estimator of  $\sigma_{\eta}^2$  where  $u = GNMA - TYGB\hat{\gamma}_{OLS}$ . That is, the statistical analysis on which Froeweiss bases his conclusions is not sound and the results he gets are likely to be due entirely to overall reduced bond market volatility which happened to coincide with the futures trading period he chose vis-a-vis the earlier period of no-futures trading that he examined.

Froeweiss conducted another set of tests using time series methods. In one test, he regressed current GNMA prices on the prices from the previous two weeks. Again the slope coefficient show no significant changes, while the estimated standard error is lower in the later period. This too, is most likely a result of coincident lower over-all capital market volatility in the futures trading period he used. The last test performed was a regression of the current week's percentage change in spot prices on the previous week's percentage change. This test showed that the pre-futures period sequence of percent changes were correlated, while the later period showed no significant serial correlation in the percentage spot price changes. This result is interpreted as reflecting an increased "efficiency" of the GNMA market in a capital market theory sense.

Figlewski's study (1981) of the price affects of the GNMA market focuses on a constructed series of monthly spot price volatility, computed as

$$V_t = \left[ \sum_{s=1}^{N_t} (P_s - P_{s-1})^2 / N_t \right]^{1/2}$$

where  $P_s$  is the spot price of GNMA's on day  $s$  in month  $t$  and  $N_t$  is the number of observations in month  $t$ .

Figlewski computes this series for GNMA 8% and GNMA 9% coupon bonds from January and February 1975 respectively, to February 1979. He looks at these two instruments

because technical factors in the futures market resulted in sometimes one and sometimes the other bond being the delivery instrument.

He uses four types of factors to explain the  $V_t$  series:

(1) volatility in related markets, measured as  $V_t$  constructed for ten-year government bonds and ten-year federal agency bonds; (2) breadth and liquidity of the cash GNMA market, measured as the volume of new issues of GNMA's for the current month plus the volume of the secondary market and the volume of new series for the future four months; (3) the level of GNMA prices; (4) futures market variables, such as average open interest for the month, total trading volume for the month, and price volatility of some GNMA futures contracts.

OLS regressions were run with  $V_t$  for GNMA 8's and GNMA 9's as dependent variables. The volatility of government bonds was not useful in explaining GNMA volatility, while the variables measuring the size of the GNMA market had generally significant negative coefficients. That is, volatility decreases as the size of the cash market increases.<sup>6</sup> Average GNMA spot price was positively related to volatility of the GNMA 8's, and was not a significant variable for the GNMA 9's.

The variables of interest are the futures market variables. The open interest was significantly positive for

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<sup>6</sup>The results show that for GNMA 9's the coefficient of secondary market volume is significantly positive in some regressions.

the 8's and the volume of trading was significantly positive for the 9's. Futures price volatility was positively related to spot price volatility.

Figlewski interprets this set of results as indicating that futures trading causes increased volatility in the spot GNMA market. Clearly, regressions such as this do not allow one to draw conclusions with respect to causation, and in this case most theoretical arguments would suggest that the increased volatility of the cash prices would cause the observed increase in trading activity. Figlewski attempts to infer the direction of causality by two arguments. First, he claims that since the positive coefficients on futures market activity occur in regressions with other "explanatory" variables, the futures market activity is not simply mirroring general bond market conditions. However, as Figlewski states earlier, the low (near zero) explanatory power of the related market volatility measure causes him to drop it in the regressions which include futures market variables. The only other variables that he includes are size variables and average price. One might easily argue that this is not a particularly complete set of variables from which to conclude that the futures market variables do not reflect other underlying causes of spot price volatility.

Secondly, he argues that futures price volatility should respond to the same factors as cash price volatility, if the causality is from cash price volatility to futures

market activity. In other regressions performed he finds that this is not so. However, there is no reason to expect prices for future delivery to measurably respond to the same factors as spot prices in his regression unless (1) the spot prices are for instruments that are deliverable on the futures contract. Figlewski does not indicate if his spot prices are for deliverable instruments or not, and he notes that only one instrument will generally be delivered, that one not being determined until the delivery date, (2) the costs of storage are reasonably stable, and of course they become less stable as the spot and futures prices become less stable, (3) his regression is fairly well specified. Overall, Figlewski's statistical analysis does not appear sensitive enough to tell us much about the price effects of futures trading in GNMA's and his causality arguments do little to justify his conclusion that futures trading increased the volatility of spot prices.<sup>7</sup> Further, the real issue is the volatility effect of the introduction of futures trading vis-a-vis no-futures trading, and on this question Figlewski's results shed no light.

Gardner (1980) performed a set of tests on the TBill market identical to those performed by Froeweiss for the GNMA market. Gardner was somewhat more careful in his choice of time periods, breaking down the data into several time periods differing in their degree of average absolute

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<sup>7</sup>Figlewski's regressions have adjusted R-squared's between 0.3 and 0.57.

deviation of daily TBill rates. He thus tried to control for other factors that might cause changes in spot price volatility by comparing results from time periods of similar volatility with and without futures trading. The period January 6, 1978 to December 31, 1978 had about as large an average absolute deviation as the January 1, 1973 to January 5, 1976 pre-futures period. (Futures trading in TBills began on January 6, 1976 on the International Monetary Market of the CME.) The period January 6, 1976 to December 31, 1977 had about half as much daily spot rate deviation as the later period, and a third as much as the earlier, no-futures period. Gardner suggests comparisons of the earliest and latest periods will show the effects of futures trading most clearly. Of course, there is an obvious difficulty in choosing comparison periods by their cash price volatility, and then testing for differences in cash price volatility. It is likely that as much evidence is covered up by this procedure as is uncovered.

Gardner's regression analysis consisted of running percentage changes in spot TBill rates on the same measure for spot CD (certificate of deposit) rates. The results of this test show that the slope coefficient was nearly the same in the pre-futures period and the later futures trading period (January - December 1978), while it was somewhat smaller in the (January 1976 - December 1977) earlier futures trading period. As noted in the discussion



of the Froeweiss paper, it is not clear what changes in this coefficient measure. The estimated standard error of the regression was lower in both futures trading periods than in the no-futures period, but the later futures trading period was higher than the earlier period. Note that this regression is subject to the same criticism as the parallel one in the Froeweiss paper.

We might note that the information on page 3 of Gardner's paper reports the fact that the TBill market is more than one and a half times as large as the CD markets in terms of outstanding face value. This indicates that the lower standard error of regression in the futures trading period may reflect the increased information flowing from the TBill futures market to the CD market, rather than reflecting a stabilizing impact of futures trading on the TBill spot market.

Gardner also performed a regression of daily TBill rates on the previous two days' rates and found that the one-day-previous coefficients were not larger (however they do not appear smaller, contrary to Gardner's statement on page 8) in the two futures trading periods than in the pre-futures period, while the two-day-previous coefficients were not different from zero in the later periods, but it was significantly negative in the pre-futures period. Also, the estimated standard errors are lowest for the lowest volatility period (1976 and 1977), higher for the more volatile 1978 period, and highest for the most volatile

1973 to 1976 period, exactly as one would expect, futures trading or not.

The last set of regressions related daily percentage changes in spot TBill rates on the previous day's percentage change. The coefficient is significant for the pre-futures trading period, but not significantly different from zero in the two periods with futures trading. The implication is that the TBill spot market became more efficient in a capital market theory sense after the start of futures trading.

Overall, this study suffers from the same two problems as does the Froeweiss study. First, how to control for other factors besides the introduction of futures trading. However, in this paper the cure may be as dangerous as the disease. Secondly, a single proxy for market conditions is not a satisfactory approach. Further, in this study there is likely another problem more serious than in the Froeweiss paper. Cross-hedging opportunities may make the CD rate respond to the introduction of futures trading in the same way it can affect the TBill rate. Hence the first regression analysis is even more suspect than the parallel regression in the Froeweiss study.

## CHAPTER 4 METHODOLOGY AND RESULTS

The review of theoretical arguments concerning the spot price effects of futures trading, presented in Chapter 2, highlighted some key points:

1. Futures trading may affect spot price volatility through its role as an information market.

2. Futures trading may affect spot price volatility by affecting the responses of spot market participants to spot market conditions, through its role as a hedging market.

3. The overall effect of futures trading on the volatility of spot price must be resolved empirically.

This chapter presents the methodology used to investigate empirically the impact of futures trading in TBills. The investigation is based on multiple regression analysis of the determination of spot TBill rates drawn from the macroeconomic literature on interest rates. Additionally, simple analysis of the raw TBill rate series is performed, paralleling earlier work on spot price effects of futures trading in commodities (see Chapter 3).

The general approach taken is to recognize theory and data limitations by specifying time periods of homogenous capital market volatility and to perform statistical analyses

in reference to these time periods. This procedure protects the results from the difficulties involved in failing to "hold other things constant" in econometric work. As noted in the discussion of the paper by Gardner (1980), one must be careful in choosing a criterion for identifying subperiods of homogeneous capital market volatility to use in testing for futures trading effects. The ideal criterion would be one that holds everything constant except for the effects of futures trading itself and those explanatory variables that are suggested by macroeconomic theory and are available.

The best available criterion is a series of a measure of volatility from some sector of the capital market that is likely to be essentially unaffected by the presence or absence of TBill futures trading. Two such series were constructed for this purpose. For the first criterion data from the Center for Research on Security Prices (CRSP) data base was used to construct estimates of the variance of daily stock market returns (New York Stock Exchange and American Stock Exchange returns, dividend adjusted) for each month from January 1970 to November 1980. From this series four recognizable subperiods were distinguished. The period September 1970 to April 1973 was a period of relative calm, with an average estimated daily variance of  $3.6 \times 10^{-5}$ . Only four observations fell outside a range of  $1.3 \times 10^{-5}$  to  $5.9 \times 10^{-5}$ , which is a sample range  $\pm$  one estimated standard error of the mean value of  $3.6 \times 10^{-5}$ . The period May 1973 to October 1975 was one of relative instability

with an average estimated daily variance of  $1.33 \times 10^{-4}$ . Only five observations are small enough to fit into the pattern of relative calm in the first period.

The period November 1975 to September 1978 was a period of relative calm in the stock market with an average estimated daily variance of  $3.76 \times 10^{-5}$ . Only six observations fell outside the range  $2.0 \times 10^{-5}$  to  $5.2 \times 10^{-5}$ . The final period, from October 1978 to November 1980 was one of mixed volatility. The average estimated daily variance is  $8.0 \times 10^{-5}$  and ten observations would fit the pattern of the preceding period of calm. There are 31 monthly observations in the first period, 30 in the second period, 35 in the third period, and 27 in the last period.

Data from the Federal Reserve System Board of Governors on daily 10-year government bond yields was used in the same manner as the stock returns. Since there was no discernible difference in the breakdown using this data series instead of the stock market series, the four periods described above were used in the subsequent research. The data on TBond yields supported an extension of the fourth period through April 1981.

TBill futures trading began in January 1976. The "calm" periods September 1970 - April 1973 and November 1975 - September 1978 are on opposite sides of the date, as are the more volatile periods May 1978 - October 1975 and October 1978 - April 1981. Thus, statistical

comparisons may be made for both relatively "calm" periods and relatively "volatile" periods before and after the introduction of futures trading in TBills.

The data series used in this chapter came from three sources: daily TBill and ten-year government bond rates are from the Board of Governors of the Federal Reserve System, January 1970 through April 1981; auction day TBill rates from Data Resources, Inc. (DRI), October 1972 - December 1980; monthly TBill rates (average of daily rates and all other monthly observations from Citibank Database, January 1980 to April 1981. The TBill rates are all calculated on a discount basis. The monthly series on TBill rates is presented in Table 5 by subperiod, along with some summary statistics. These rates are plotted, by period, in Figures 2 through 5.

### Total Variance Analysis

Testing for the effects of futures trading on the volatility of the underlying spot price requires, of course, a definition of volatility. As a first definition, consider the magnitude of raw fluctuations in price series day by day. Such a concept of volatility implies two things (1) there is some cost, social or private, that increases with the magnitude of price fluctuations, and (2) any activity that increases such fluctuations should be evaluated for possible prohibition. Statistically, there is a third implication-- changes in the magnitude of these spot price fluctuations are due to the activity in question, e.g., the existence of futures trading.

A test of the price effects of futures trading, given that these three conditions are satisfied, is based on the estimated coefficients of variation of daily and weekly TBill rates. The coefficient of variation is the ratio of the sample standard deviation to the sample mean. This measure of volatility allows comparison of volatility between samples with different means to be made on a per unit of mean basis. Use of the coefficient of variation rather than the sample variance eliminates the bias that could result from one period having a lower mean than another and a lower absolute variance, while being relatively more volatile.

The results are presented in Tables 7 -10. Tables 7 and 8 show results from auction day TBill rates and their first differences.<sup>1</sup> Tables 9 and 10 present results from daily TBill rates and their first differences.

Comparison of the coefficients of variation (c.v.) for comparable ("calm") periods 1 and 3 in Table 7 and comparable ("volatile") periods 2 and 4 indicate that the futures trading periods had greater auction day TBill rate volatility than the non-futures trading periods. The daily TBill rate data in Table 9 show the same pattern for periods 2 versus 4, but lower volatility in "calm" futures trading period 3 than "calm" no-futures period 1.

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<sup>1</sup>Note that the auction day rates are from October 1972 through December 1980 only.

Tables 8 and 10 are based on the first differences of the series in Tables 7 and 9 respectively. First differencing the data on TBill rates is another means of controlling for differences in the sample means of the raw data in the form periods, as well as trends or nonstationarity in the TBill rate series. The Table 8 results indicate that the variance of the change in auction-day rates is lower in period 3 versus period 1, and higher in period 4 versus period 2. The results in Table 10 on first differences of the daily TBill rates are similar.

Overall, this simple analysis presents mixed conclusions. When capital markets are relatively calm (periods 1 and 3), the presence of futures trading does not appear to increase spot TBill rate volatility. When capital markets are relatively volatile (periods 2 and 4), futures trading appears to increase spot TBill rate volatility. Of course, the confidence one can have in these conclusions depends on both the faith one can have in the ceteris paribus assumption and on the appeal of the definition of volatility as the relative size of the fluctuations in the spot TBill rate.

#### Multiple Regression Analysis

Consideration of these last two points leads to a different test and a different notion of volatility. Certainly the selection of similar time periods is only a rough means of holding other things constant. A much more fundamental means is through multiple regression



analysis which controls specifically for changes in important factors other than the existence or non-existence of futures trading. Application of a regression model of interest rate determination to the separate time periods allows one to attribute changes in the character of the unexplained (non-systematic) portion of interest rates to the introduction of futures trading. Thus, the relevant concept of volatility is the volatility of the random disturbance term in a macroeconometric model on interest rates.

This concept is a particularly attractive one. Interest rates are prices for the services of capital, and behave much like other prices. That is, they are determined by the aggregation of individual economic agents' decisions, based on various information they may have about relevant economic variables and relationships. When information suggests changes in these variables, a well-functioning capital market should experience changes in interest rates. Lack of responsiveness in interest rates to changing conditions may be a sign of a severely inefficient capital market. Controlling for such changes through multiple regression analysis, coupled with the careful selection of comparable test periods, gives one much more confidence in attributing possible changes in the volatility of the error term to the introduction of futures trading. If futures trading increases the magnitude of the unexplained

spot rate fluctuations, it may be said to increase the volatility of spot rates.

The variance and the coefficient of variation will be used to measure the volatility of the random disturbance term. The coefficient of variation is defined as the ratio of estimated standard error of the regression to the mean of the TBill rate for each period. As discussed above, the coefficient of variation is a relative measure of volatility and controls for differences in sample means across time periods.

The macroeconomics literature contains several models of the determination of interest rates which could be used to test the hypothesis that futures trading increases the volatility of spot TBill rates. These models fall generally into two classes: those which are based on simultaneous equation macroeconomic models of the entire (simplified) economy, and those which are based on partial equilibrium approaches to interest rate changes. Two models are used in this study, one of each type.<sup>2</sup> The first model is similar to the one found in Sargent (1973), Levi and Makin (1978, 1980) and Bomberger and Frazer (1981), and is of the complete system type. The second model is similar to the one in Okun (1963) and to several other models in the literature.

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<sup>2</sup> Both models will be estimated using monthly data. The data sources are as noted above (page 81 ); Tables 3-6 contain the monthly TBill rates and summary statistics, by sub-period. Figures 2-5 plot the TBill rate series by sub-period.

The Sargent-type model will be discussed first.

Define:

$y_t$  as the log of real output

$y_{ct}$  as the log of real capacity output

$p_t$  as the log of the price level for time  $t$

$\Pi_t = p_t - p_{t-1}$  as the inflation rate for time  $t$

$\Pi_t^e$  as the expectation of  $\Pi_t$ .

$m_t$  as the log of nominal money balances

$r_t$  as the nominal interest rate on 90-day TBills

$z_t$  as other exogenous macro variables

and consider the following three equation system

$$(1) \quad y_t = y_{ct} + \gamma[\Pi_t - \Pi_t^e] + u_{1t}$$

$$(2) \quad y_t = y_{ct} + \alpha_0 + \alpha_1(r_t - \Pi_t^e) + \alpha_2 z_t + u_{2t}$$

$$(3) \quad m_t = \beta_0 + y_t + \beta_1 r_t + u_{3t}$$

Equation (1) is an expectations augmented Phillips Curve, or an aggregate supply curve. This is the Lucas type supply curve where deviations of real output from capacity output are positively related to the error in the inflation forecast so that  $\gamma > 0$ . For a complete discussion see Lucas and Rapping (1969) and Lucas (1973).

Equation (2) is an aggregate demand curve (IS curve), where the deviations of real demand from capacity output are related to the expected real rate of interest ( $\alpha_1 < 0$ ). The variables  $z_t$  include fiscal policy variables.<sup>3</sup>

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<sup>3</sup>The available monthly series for such variables are federal debt outstanding and the federal surplus or deficit. Since

Equation (3) is a simple Keynesian portfolio balance equation. The terms  $u_{1t}$ ,  $u_{2t}$ , and  $u_{3t}$  are mutually uncorrelated, mean zero disturbance terms. The endogenous variables are  $y_t$ ,  $r_t$ ,  $\Pi_t$ ,  $\Pi_t^e$  and the exogenous variables are  $m_t$ ,  $z_t$ ,  $y_{ct}$ .

Solve the equations to get  $r_t$  in terms of  $\Pi_t^e$ , the exogenous variables, and the disturbances

$$(4) \quad r_t = \frac{1}{\delta} [\alpha_0(1+\gamma) + \gamma\beta_0 + \gamma y_{ct} + \alpha_2(1+\gamma)z_t + \gamma(p_{t-1} - m_t) - (\alpha_1 - \gamma + \gamma\alpha_1) \Pi_t^e - u_{1t} + (1+\gamma)u_{2t} + \gamma u_{3t}]$$

where  $\delta = -\alpha_1 - \gamma\beta_1 - \alpha_1\gamma$  and  $p_{t-1}$  was subtracted from both sides of equation (3) before solving.

Equation (4) may be rewritten as

$$(5) \quad r_t = A_0 + A_1(y_{ct} - m_t + p_{t-1}) + A_2 z_t + A_3 \Pi_t^e + \varepsilon_t$$

where  $A_0 = \frac{1}{\delta}(\alpha_0(1+\gamma) + \gamma\beta_0)$ ,  $A_1 = \frac{\gamma}{\delta}$ ,  $A_2 = \frac{\alpha_2(1+\gamma)}{\delta}$ ,

$A_3 = \frac{-(\alpha_1 - \gamma + \gamma\alpha_1)}{\delta}$ ,  $\varepsilon_t = u_{1t} + (1+\gamma)u_{2t} + \gamma u_{3t}$ .  $\varepsilon_t$  is

a random disturbance, presumed to be normally distributed with mean zero.

Equation (5) is not a reduced form equation due to the presence of the endogenous variable  $\Pi_t^e$ , the expected

<sup>3</sup> the surplus/deficit variable had no effect on any results,  $z_t$  contains only debt outstanding. The variable  $y_{ct}$  was measured as the log of the trend in real personal disposable income from 1/65 to 4/81.

inflation rate at time  $t$ . Now impose the rational expectations hypothesis

$$(6) \Pi_t^e = E[\Pi_t \mid \phi_t],$$

where  $\phi_t$  is the information set available to agents when they form their expectations. Equation (6) says that  $\Pi_t^e$  is the mathematical conditional expectation of the inflation rate, and in particular, forecast errors

$$(7) v_t = \Pi_t - \Pi_t^e$$

are uncorrelated with all elements of the set  $\phi_t$ . Equations (5) and (6) comprise one of the interest rate models used to examine the effect of futures trading on spot price volatility.

The second interest rate model is taken from Okun (1963) and Feldstein and Chamberlain (1973) although it is representative of models in several other papers. (See Pesando (1976), Levi and Makin (1978), Yohe and Karnosky (1969), Feldstein and Eckstein (1970).<sup>4</sup> The estimating equation is

$$(8) r_t = B_0 + B_1 \text{LRMB}_t + B_2 \Pi_t^e + B_3 \text{LFD}_t + B_4 \text{LPDI}_t \\ + B_5 \text{LP}_t + \eta_t$$

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<sup>4</sup>All of these papers employ quarterly, semi-annual, or annual observations, generally ending prior to 1975. Note that Okun's models do not contain inflation variables. His data set contained quarterly observations from 1946-1959.

where

$r_t$  = 90-day TBill rate

$LRMB_t$  = log of real monetary base

$\pi_t^e$  = expected inflation rate

$LFD_t$  = log of federal debt outstanding

$LPDI_t$  = log of real personal disposable income

$LP_t$  = log of potential real personal disposable income

$\eta_t$  = normally distributed, mean zero random error.<sup>5</sup>

Equation (8) is representative of several other interest rate equations that have been estimated in the literature. In general these models are based on partial equilibrium analyses of the determinants of the interest rate, rather than being based on a complete, if restrictive, macro-economic model as in equations (5) and (6).

The motivation for the inclusion of income and money variables is essentially the Keynesian liquidity preference function. The use of the money base variable rather than money supply is due to the more direct control the Fed has over the money base as a means of implementing policy changes. The two income variables are designed to cover two separate effects. The variable  $LP_t$  is used to reflect secular growth in output potential, while the variable  $LPDI_t$  recovers cyclical factors in interest rates.

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<sup>5</sup>Okun defines potential output as actual GNP  $(1 + .032(\text{actual unemployment} - 4\%))$ . This same computation is applied to real personal disposable income to generate  $LP$ .

Okun argues that there are strong a priori grounds for including both the level and maturity composition of federal debt outstanding (Okun, 1963).<sup>6</sup> Monthly observations on the composition of federal debt are not available, and the coefficients on the two components of federal debt in Okun's paper are very close to each other. Each coefficient is easily within one standard error of the other, and it seems no harm is done by grouping the two components into total federal debt outstanding.<sup>7</sup>

The expected inflation variable in equation (8) is unobservable, as in equation (5). This model is completed by attaching equation (6), and both models (5) and (6) and (8) and (6) are estimated by identical methods.

#### Ordinary Least Squares Estimation

Two approaches are taken in estimating the systems (5) and (6) and (8) and (6), ordinary least squares (OLS) and instrumental variables (I.V.) estimation. The least squares procedure is described first for both models. The instrumental variables technique is described later as a more general method of estimation.

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<sup>6</sup>To measure the effect of the maturity structure he uses two total debt components--less than 5 years and more than five years to maturity, and a measure of the average maturity of the federal debt.

<sup>7</sup>Note that Okun did not find the average maturity of the federal debt to be a significant determinant of TBill rates.

Both approaches involve two stages of estimation.

For the first stage, rewrite (7) as

$$(9) \quad \Pi_t = E[\Pi_t \mid \phi_t] + v_t.$$

Consider that the expectation in (9) is taken to minimize the mean square error of prediction. Then  $\Pi_t^e$  is found as the least squares projection of  $\Pi_t$  on  $\phi_t$ . To implement this idea empirically, regress  $\Pi_t$  on a subset of  $\phi_t$  using OLS

$$(10) \quad \Pi_t = \gamma \underline{\phi_t} + u_t.$$

From (10) obtain an estimate of  $\Pi_t^e$ ,  $\hat{\Pi}_t^e = \hat{\gamma} \underline{\phi_t}$ , where  $\underline{\phi_t}$  is a subset of elements of  $\phi_t$ . Note that

$$(11) \quad \Pi_t - \hat{\Pi}_t^e = e_t$$

where  $e_t$  is the regression residual from (10) and

$$\text{cov}(e_t, \underline{\phi_t}) = 0.$$

The requirements for  $\hat{\Pi}_t^e$  are that the residual error term  $e_t$  be serially uncorrelated and  $\hat{\Pi}_t^e$  must be highly correlated with  $\Pi_t$ . In the present case, where the monthly observation of the 90-day TBill rate is the dependent variable, the 90-day inflation rate is the inflation rate of matching horizon. However, it was not possible to form a series  $\hat{\Pi}_t^e$  from equation (10) for the 90-day inflation rate with serially uncorrelated residuals.<sup>8</sup> The procedure

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<sup>8</sup>This is a result of overlapping horizons for the monthly series of three month inflation.



used was to estimate equation (10) for 30-day inflation rates (annualized to match the annualized TBill rate series). The set  $\phi_t$  included lagged values of the one-month inflation rate ( $t-1$  and  $t-2$ ), lagged values of growth in the money supply  $M1A(t-1$  and  $t-2)$ , lagged TBill rates ( $t-1$ ) and lagged growth rates of real personal disposable income ( $t-1$ ). The data are all monthly observations obtained from the Citibank data base.

This procedure essentially assumes that the current expectation of the inflation rate over the next three months is the same as the expected inflation rate over the next month. This assumption appears reasonable. Table 11 presents the results of the regressions (10) with  $\phi_t$  as described above. The series  $\hat{\pi}_t^e$  was formed for three periods: 1/65-7/71, 8/71-4/74, 5/74-11/80. These three periods were used to separate out the wage/price controls period, 8/71-4/74. Note that over the entire sample period the correlation of  $\hat{\pi}_t^e$  with the actual three month rate of inflation is over 0.80.

In the ordinary least squares approach, the series  $\hat{\pi}_t^e$  is used directly in the estimation of equations (5) and (8). The equations are estimated by the Cochrane-Orcutt procedure for the presence of first-order autocorrelation. This procedure requires the strong assumption that  $\hat{\pi}_t^e$  equals  $\pi_t^e$ ; otherwise the procedure suffers from the errors in variable problem.<sup>9</sup> The estimates from this

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<sup>9</sup>Note that many researchers fail to mention this

procedure for equation (5) are presented in Table 12. The estimates for equation (8) are presented in Table 14.<sup>10</sup>

Note in Table 12 that the coefficients display considerable variation across the four time periods. In particular, the estimate of  $A_1$ , while significantly positive when estimated over the entire sample, changes sign in period four and is not significantly different from zero in any subperiod. The coefficient  $A_2$  behaves much the same way. While the theory would suggest  $A_1 > 0$ , the expected sign for  $A_2$  is not so clear. If increases or decreases in federal debt reflect expansive and restrictive fiscal policies, respectively, the expected sign is positive. If changes in debt outstanding reflect tax revenue shortfalls during downturns, the sign may be negative. Overall, it appears that the latter effect is stronger, though the former effect seems to be stronger of late. The coefficient estimate on  $\pi_t^e$  is uniformly positive, as expected.

Several slight modifications of the two interest rate equations were tried. The model (5) and (6) was reestimated without the federal debt variable. The results are shown in Table 13. The coefficient of expected inflation,  $A_3$ , is essentially unchanged in the four subperiods. The

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<sup>9</sup> problem. They construct an "expected inflation" and use it directly in an interest rate equation with no reference to the bias in their results due to the measurement error. See, for example, Pesando (1976), and Feldstein and Chamberlain (1973). For an example where the problem is recognized, see Lahiri (1976).

<sup>10</sup> The numbers in parenthesis in all tables are the calculated t-statistics.

coefficient of  $(y_{ct} - m_t + p_{t-1})$  is changed, however. It is now positive in periods 3 and 4 (and significantly greater than zero) and negative in period 2. Also, the variance of the weekly money supply was calculated for each month and this uncertainty variable was included as a regressor for both models (5) and (8). There was very little change in any of the coefficients, the R-squared's (unadjusted) were slightly higher, and there was no change in the pattern of volatility behavior across the four periods when this variable was included. Lastly, the third time period, 11/75-10/78 was shortened to 1/75-10/78, reflecting the fact that futures trading actually began in January 1976. As expected, the estimates from this shorter time period had no effect on the measurements of volatility for the third time period.

These results for both models can be used to test the hypothesis that futures trading in TBills has affected the volatility of spot TBill rates under the assumption that  $\pi_t^e = \pi_t^e$ . The estimated coefficients of variation will provide the evidence on the volatility effects of future trading. As noted above, these coefficients are standardized measures of volatility that allow comparison across samples with different mean values for the monthly TBill rate. They are calculated as the ratio of the standard error of the regression divided by the mean TBill rate for each period. The results are presented in the table below for the three regression models in Tables 12, 13, and 14.

<u>Model</u>	<u>c.v. period 3</u>	<u>c.v. period 1</u>	<u>c.v. period 4</u>	<u>c.v. period 2</u>
as in Table 12	0.055	0.130	0.110	0.091
as in Table 13	0.055	0.127	0.113	0.091
as in Table 14	0.068	0.108	0.098	0.071

The evidence in the table shows that for the relatively calm periods with and without futures trading, period 3 versus period 1, the coefficient of variation is uniformly higher for the non-futures trading period, across all three regression models. The reverse is true for the comparable periods 4 and 2. The futures trading period has uniformly larger coefficients of variation across the three regression equations. Exactly the same result is obtained from F-tests on the error variance estimates from the three equations.

<u>Model</u>	<u><math>\hat{\sigma}_\epsilon^2, 3/\hat{\sigma}_\epsilon^2, 1</math></u>	<u>critical F*</u>	<u><math>\hat{\sigma}_\epsilon^2, 4/\hat{\sigma}_\epsilon^2, 2</math></u>	<u>critical F*</u>
as in Table 12	0.26	1.84/2.39	3.51	1.92/2.53
as in Table 13	0.27	1.84/2.39	3.64	1.92/2.53
as in Table 14	0.59	1.92/2.53	4.59	1.96/2.62

\*Values are presented as F .05/F .01 and are approximate.

It is important to note that these results are from regression models that are based on the assumption that  $\Pi_t^e$  equals the unobserved series  $\Pi_t^e$ . The econometric technique described in the next section gives consistent estimates even if  $\hat{\Pi}_t^e$  does not equal  $\Pi_t^e$ .

### Instrumental Variables Estimation

Consistent estimation of unobservable variable models with rational expectations, such as (5) and (6), has been recently considered by McCallum (1976) and Cumby, Huizinga and Obstfeld (1980) among others. (See Wallis (1980) and the references given there.) Their technique is essentially the instrumental variable solution to the errors in-variables problem, with the instrument for  $\Pi_t$  being the least squares projection  $\hat{\Pi}_t^e$ . The approach may be illustrated as follows.

The equation of interest contains an unobservable expectations variable,  $\Pi_t^e$ . Given rational expectations one may write an equation such as (6), where  $\phi_t$  contains the information set available at the time  $\Pi_t^e$  is formed, including all past values of relevant variables and the structure of the system which generates the endogenous variables. Suppose the equation of interest is

$$(12) \quad y_t = \gamma_1 \Pi_t^e + \gamma_2 x_t + \varepsilon_t$$

where  $\varepsilon_t$  is white noise,  $E[\varepsilon_t] = 0$  and  $E[\varepsilon_t^2] = \sigma_\varepsilon^2$ .

Replace  $\Pi_t^e$  with  $\Pi_t - v_t$  from (7)

$$(13) \quad y_t = \gamma_1 \Pi_t + \gamma_2 x_t + \varepsilon_t - \gamma_1 v_t$$

Now (13) has a measurement error problem and OLS will not provide consistent estimates of  $\gamma_1$ ,  $\gamma_2$  and  $\sigma_\varepsilon^2$ . McCallum and Cumby, Huizinga and Obstfeld (CHO) suggest finding

instruments for  $\Pi_t$  and  $x_t$  and using instrumental variable estimation of (13) to get coefficient estimates. The obvious instrument for  $\Pi_t$  is  $\hat{\Pi}_t^e$  since it is highly correlated with  $\Pi_t$  (see Table 5) and necessarily uncorrelated with the composite error term,  $\varepsilon_t - \gamma_1 v_t = \omega_t$ . (This is true because  $\varepsilon_t$  is white noise and  $\hat{\Pi}_t^e$  is a linear combination of lagged variables, and  $v_t$  is uncorrelated with all of  $\phi_t$  by the Rational Expectations Hypothesis, hence uncorrelated with  $\hat{\Pi}_t^e$ .)

The variable(s)  $x_t$  may serve as its (their) own instrument if  $\phi_t$  contains  $x_t$ . Otherwise  $v_t$  will be correlated with  $x_t$  and a suitable instrument must be found. Again the Rational Expectations Hypothesis provides an answer:  $x_{t-1}$  is necessarily uncorrelated with the composite disturbance term and is a good instrument for  $x_t$ , where one is required.

Under the assumptions given above (rational expectations and  $\varepsilon_t$  white noise) instrumental variable estimation provides consistent estimates of the  $\gamma$ 's and of the variance of the composite error term  $\varepsilon_t - \gamma_1 v_t$  in equation (13). The best available means of obtaining an estimate of  $\sigma_\varepsilon^2$  from this procedure is to use  $\hat{\sigma}_e^2$ , the estimated residual variance from the first stage regression  $\Pi_t = \hat{\Pi}_t^e + e_t$ , as an estimate of  $\hat{\sigma}_v^2$ . A range for  $\hat{\sigma}_\varepsilon^2$  may be computed from

$$(14) \quad \hat{\sigma}_\omega^2 = \hat{\sigma}_\varepsilon^2 + \hat{\gamma}_1^2 \hat{\sigma}_v^2 - 2\hat{\gamma}_1 \theta \hat{\sigma}_\varepsilon \hat{\sigma}_v$$

where  $\hat{\sigma}_\omega^2$  is the estimated composite error variance from the I.V. estimation of (13) and  $\theta$  is the correlation

coefficient between  $\varepsilon$  and  $v$ . Allowing  $\theta$  to vary from -1 to 1 provides bounds for  $\hat{\sigma}_{\varepsilon}^2$  in each period, and coefficients of variation can be computed from  $\hat{\sigma}_{\varepsilon}^2$ .

This estimation procedure was applied to the two models (5) and (8) using the  $\hat{\Pi}_t^e$  series as described above as the instrumental variable for  $\Pi_t^e$ . Instruments for the other right-hand side variables were their own lagged values. The estimated Durbin-Watson statistics for both models in all time periods indicate positive first-order autocorrelation. This is the same pattern indicated by the Cochrane-Orcutt procedure in Tables 12-14. Hence the necessary assumptions for consistency are violated, and the estimated error variances from this instrumental variables approach cannot be used to test the effects of futures trading on spot price volatility. The next section describes a consistent estimation method in the presence of autocorrelated error terms. Error variance estimates from this procedure can be used to test for volatility effects of futures trading.<sup>12</sup>

### Autocorrelation Correction

Autocorrelation in this model causes biased coefficients since the instruments contain lagged endogenous variables

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<sup>12</sup>The performance of the Okun-type model was not satisfactory. The expected sign of the coefficient of  $\Pi_t^e$  is positive but the estimates  $\hat{B}_2$  were negative in three of four periods. Further, the estimate of  $\hat{\sigma}_{\omega}^2$  in this model for period 4 was far larger than for the other model and other periods. This does not appear to be warranted by the data. Finally, the estimated autocorrelation for this model (not shown) is negative, while Tables 12-14

which will be correlated with an autoregressive error term. To circumvent this problem, CHO suggest using m-period lagged endogenous variable as instruments rather than once-lagged endogenous variables, where m is one plus the length of the autoregressive process,  $\varepsilon_t = \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \dots + \theta_{m-1} \varepsilon_{t-(m-1)} + \mu_t$ ,  $\mu_t$  white noise. Also, they suggest using m-period or (m-1) period lagged exogenous variables as instruments, depending on the most recent variables included in the information set,  $\phi_t$ .

To obtain consistent estimates of the coefficients in (12) when the error term  $\varepsilon_t$  follows a first-order autoregressive scheme, first write the quasi-differenced expression for equation (13) as

$$(15) \quad y_t = \rho y_{t-1} + \gamma_1 \Pi_t - \rho \gamma_1 \Pi_{t-1} + \gamma_2 x_t - \rho \gamma_2 x_{t-1} \\ + \varepsilon_t - \gamma_1 v_t - \rho \varepsilon_{t-1} + \rho \gamma_1 v_{t-1}.$$

Note that  $\varepsilon_t - \gamma_1 v_t - \rho \varepsilon_{t-1} + \rho \gamma_1 v_{t-1} = \omega_t - \gamma_1 v_t + \rho \gamma_1 v_{t-1}$ , where  $\varepsilon_t = \rho \varepsilon_{t-1} + \omega_t$ . Estimate (15) by the instrumental variables method. The instruments used for the contemporaneous variables in this procedure are the optimal (minimum mean-square-error) forecasts of the right-hand side variables in (15) based only on information available at time t-2. The instruments for the lagged endogenous variables are also forecasts based on information up through t-2.

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<sup>12</sup>and the Durbin-Watson statistics indicate positive first order autocorrelation. For these reasons this model is not pursued further.



The instruments for lagged exogeneous variables are their twice-lagged values. This instrumental variables procedure yields consistent parameter estimates, and particularly, a consistent estimate of  $\hat{\rho}$ . Use this estimate to transform the variables (and the instruments) and estimate the quasi-differenced form of (13) by the instrumental variables method. The resulting estimates of the coefficients are consistent.

Writing out explicitly the quasi-differenced form from the model (5) and (6),

$$\begin{aligned}
 (16) \quad r_t - \rho r_{t-1} = & A_0(1-\rho) + A_1 [(y_{ct} - m_t + p_{t-1}) \\
 & - \rho(y_{ct-1} - m_{t-1} + p_{t-2})] \\
 & + A_2 [z_t - \rho z_{t-1}] + A_3 [\pi_t - \rho \pi_{t-1}] \\
 & + \varepsilon_t - A_3 v_t - \rho \varepsilon_{t-1} + \rho A_3 v_{t-1}
 \end{aligned}$$

or,

$$\begin{aligned}
 (17) \quad r_t^* = & A_0^* + A_1 (y_{ct} - m_t + p_{t-1})^* + A_2 z_t^* \\
 & + A_3 \pi_t^* + \omega_t - A_3 v_t^*
 \end{aligned}$$

where  $\rho$  is the autocorrelation coefficient in the error term  $\varepsilon_t$ . In (17), let  $\theta_t = \omega_t - A_3(v_t - \rho v_{t-1})$ . Then the variance of the error term ( $\theta_t$ ) is

$$\begin{aligned}
 (18) \quad V(\theta_t) = & V(\omega_t) + A_3^2 V(v_t) + A_3^2 \rho^2 V(v_{t-1}) \\
 & - 2 A_3 \text{cov}(\omega_t, v_t) + 2 A_3 \rho \text{Cov}(\omega_t, v_{t-1}) \\
 & - 2 A_3^2 \rho \text{Cov}(v_t, v_{t-1}).
 \end{aligned}$$

Now,  $\text{Cov}(v_t, v_{t-1}) = 0$  by the rational expectations hypothesis. Also, assume that  $V(v_t) = V(v_{t-1})$  and that the other covariances are zero so that (18) becomes

$$(19) \quad V(\theta_t) = V(\omega_t) + A_3^2 (1+\rho^2) V(v_t).$$

Suppose an estimate of  $V(v_t)$  were available. Then equation (19) could be used to obtain estimates of the variance of the error term  $\omega_t$ , the innovation in the structural disturbance of the equation of interest, (5). This is the error term whose variance is of importance for testing the effects of futures trading in TBills on the spot TBill rate volatility. The variance of this random innovation in the spot TBill rate cannot be directly obtained since there is no available estimate of  $V(v_t)$ . However, a test can be conducted using the estimated variance of  $\theta_t$  in the four time periods which yields information on the pattern of variance of  $\omega_t$  across the comparable periods with and without futures trading. This test will be discussed below, after the estimates from equation (17) are discussed.

The estimation procedure described on page 17 was carried out for the model (5) and (6). Table 15 presents the estimation results.<sup>15</sup> Note that the estimate of the

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<sup>15</sup> The coefficient estimates of equation (15) are not shown. They are available from the author. The first-order autocorrelation coefficient estimate, shown in Table 15 is 0.910.

autocorrelation coefficient,  $\hat{\rho}$ , is obtained from data over all four periods, 9/70-4/81.

As discussed above, the expected signs for  $A_1$  and  $A_3$  are positive.  $A_1$  is positive in periods 1 and 3, negative in periods 2 and 4.  $A_3$ , the coefficient of expected inflation, is positive in all periods except period 2. The coefficient on federal debt outstanding,  $A_2$ , is uniformly positive.

The column labeled  $R^2$  in Table 15 contains a measure of the goodness-of-fit for the model (5) and (6) in each time period. It is not exactly an  $R^2$  as in the usual least squares procedure, but is a number between one and zero which reflects the explanatory power of the model. Higher values of " $R^2$ " indicate more explanatory power in the model.<sup>16</sup>

Turn now to the evidence relating to the volatility effects of futures trading. As noted in equation (19) the estimated variance in Table 15 is a combination of two variances that are not separately estimable. However, under the assumption that  $V(v_t)$  is constant over all four periods,

the ratios  $\frac{\hat{\sigma}_{\theta}^2 m, 3}{\hat{\sigma}_{\theta}^2, 1}$  and  $\frac{\hat{\sigma}_{\theta}^2, 4}{\hat{\sigma}_{\theta}^2, 2}$  are almost equal to the

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<sup>16</sup>The calculated goodness-of-fit measure is equal to the

ratio  $\frac{\hat{B}'X'Z(Z'Z)^{-1}Z'XB}{\hat{B}'X'Z(Z'Z)^{-1}Z'XB + \sum \hat{u}^2}$ , where  $\hat{B}$  is the estimated coefficient vector,  $z$  is the instrument matrix. This ratio is based on the chi-square variate

ratios  $\frac{\hat{\sigma}_{\omega}^2, 3 + \text{constant}}{\hat{\sigma}_{\omega}^2, 1 + \text{constant}}$  and  $\frac{\hat{\sigma}_{\omega}^2, 4 + \text{constant}}{\hat{\sigma}_{\omega}^2, 2 + \text{constant}}$ . Thus, the

first two ratios may be used as biased measures of the

ratios  $\frac{\hat{\sigma}_{\omega}^2, 3}{\hat{\sigma}_{\omega}^2, 1}$  and  $\frac{\hat{\sigma}_{\omega}^2, 4}{\hat{\sigma}_{\omega}^2, 2}$ , the bias being towards one.<sup>17</sup>

That is, computing the variance ratios from Table 15 provides some information on whether  $H_0$  or  $H_a$  is correct:

$H_0: \sigma_{\omega}^2, \text{ futures trading} = \sigma_{\omega}^2, \text{ no futures trading}$

$H_a: \sigma_{\omega}^2, \text{ futures trading} > \sigma_{\omega}^2, \text{ no futures trading}$

If the computed ratio is less than one, the true ratio of variances of  $\omega$  in each time period is even smaller than that computed from the  $\hat{\sigma}_{\theta}^2$ 's. If the computed ratio is greater than one, the true ratio is even higher. The computed ratios are shown below with the critical F values<sup>18</sup>

$$\hat{\sigma}_{\theta}^2, 3 / \hat{\sigma}_{\theta}^2, 1 = 0.80 \quad \hat{\sigma}_{\theta}^2, 4 / \hat{\sigma}_{\theta}^2, 2 = 8.52$$

$$\text{critical F} = 1.96/2.62 \quad \text{critical F} = 1.96/2.62$$

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16

$\frac{\hat{B}'X'Z(Z'Z)^{-1}Z'XB}{\sigma^2}$ , which is a test statistic for the hypothesis that the B's are jointly zero. The  $\hat{u}$  is the residual from instrumental variable estimation and  $\sigma^2$  is the true error variance.

<sup>17</sup>Note that the square of the estimate of  $A_3$  in Table 15 will be small, and not very different across the sample periods.

<sup>18</sup>F-values are approximate and are presented as F at 5%/F at 1% levels.

These results reflect the same pattern as the previous tests. Comparable periods 1 and 3 give the result that futures trading does not increase spot price volatility, while comparable periods 2 and 4 support the alternative hypothesis. While this test was developed based on the assumption that the covariance terms in equation (18) are all zero, this assumption is stronger than required. All that is required for the test to be valid is that the covariances are constant over time, or at least constant between the comparable periods.

The coefficients of variation may be computed from the estimated variances in Table 15. Under the same assumptions given above for the validity of the F-tests, these coefficients of variations provide evidence on the volatility effects of futures trading on the spot TBill rate.

<u>c.v. period 3</u>	<u>c.v. period 1</u>	<u>c.v. period 4</u>	<u>c.v. period 2</u>
0.07	0.10	0.21	0.11

The coefficients of variation show the same pattern as the F-ratios. For the calm periods futures trading does not increase spot TBill rate volatility. For the two more volatile periods, the futures trading period has the higher volatility of spot rates.

The next chapter summarizes the results and presents the conclusions of this study.

TABLE 3  
MONTHLY TBILL RATES AND SUMMARY STATISTICS,  
PERIOD 1, 9/70-4/73

<u>OBS</u>	<u>Rate</u>	<u>Date</u>
1	6.244	9/70
2	5.927	10/70
3	5.288	11/70
4	4.860	12/70
5	4.494	1/71
6	3.773	2/71
7	3.323	3/71
8	3.780	4/71
9	4.139	5/71
10	4.699	6/71
11	5.405	7/71
12	5.078	8/71
13	4.668	9/71
14	4.489	10/71
15	4.191	11/71
16	4.023	12/71
17	3.403	1/72
18	3.180	2/72
19	3.723	3/72
20	3.723	4/72
21	3.648	5/72
22	3.874	6/72
23	4.059	7/72
24	4.014	8/72
25	4.651	9/72
26	4.719	10/72
27	4.774	11/72
28	5.061	12/72
29	5.307	1/73
30	5.558	2/73
31	6.054	3/73
32	6.289	4/73

Mean: 4.57556250

Minimum Value: 3.18000000

Standard Deviation: 0.86696935

Maximum value: 6.28900000

C.V.: 18.948

Range: 3.10900000

Source: Citibank Data Tape.

TABLE 4  
MONTHLY TBILL RATES AND SUMMARY STATISTICS,  
PERIOD 2, 5/73-10/75

<u>OBS</u>	<u>Rate</u>	<u>Date</u>
1	6.348	5/73
2	7.188	6/73
3	8.015	7/73
4	8.672	8/78
5	8.478	9/73
6	7.155	10/73
7	7.866	11/73
8	7.364	12/73
9	7.755	1/74
10	7.060	2/74
11	7.986	3/74
12	8.229	4/74
13	8.430	5/74
14	8.145	6/74
15	7.752	7/74
16	8.744	8/74
17	8.363	9/74
18	7.244	10/74
19	7.585	11/74
20	7.179	12/74
21	6.493	1/75
22	5.583	2/75
23	5.544	3/75
24	5.694	4/75
25	5.315	5/75
26	5.193	6/75
27	6.164	7/75
28	6.463	8/75
29	6.383	9/75
30	6.081	10/75

Mean: 7.14903333                      Minimum Value: 5.19300000

Standard Deviation: 1.07365292      Maximum Value: 8.74400000

C.V.: 15.018                              Range: 3.55100000

Source: Citibank Data Tape.

TABLE 5  
MONTHLY TBILL RATES AND SUMMARY STATISTICS,  
PERIOD 3, 11/75-10/78

<u>OBS</u>	<u>Rate</u>	<u>Date</u>
1	5.468	11/75
2	5.504	12/75
3	4.961	1/76
4	4.852	2/76
5	5.047	3/76
6	4.878	4/76
7	5.185	5/76
8	5.443	6/76
9	5.278	7/76
10	5.153	8/76
11	5.075	9/76
12	4.030	10/76
13	4.810	11/76
14	4.355	12/76
15	4.597	1/77
16	4.662	2/77
17	4.613	3/77
18	4.540	4/77
19	4.942	5/77
20	5.004	6/77
21	5.145	7/77
22	5.500	8/77
23	5.770	9/77
24	6.188	10/77
25	6.160	11/77
26	6.063	12/77
27	6.448	1/78
28	6.457	2/78
29	6.319	3/78
30	6.306	4/78
31	6.430	5/78
32	6.707	6/78
33	7.074	7/78
34	7.036	8/78
35	7.836	9/78

Mean: 5.56391429

Minimum Value: 4.35500000

Standard Deviation: 0.85204420

Maximum Value: 7.83600000

C.V.: 15.314

Range: 3.48100000

Source: Citibank Data Tape.



TABLE 6  
MONTHLY TBILL RATES AND SUMMARY STATISTICS,  
PERIOD 4, 10/78-4/81

<u>OBS</u>	<u>Rate</u>	<u>Date</u>
1	8.132	10/78
2	8.787	11/78
3	9.122	12/78
4	9.351	1/79
5	9.265	2/79
6	9.457	3/79
7	9.493	4/79
8	9.579	5/79
9	9.045	6/79
10	9.262	7/79
11	9.450	8/79
12	10.132	9/79
13	11.472	10/79
14	11.868	11/79
15	12.071	12/79
16	12.036	1/80
17	12.814	2/80
18	15.526	3/80
19	14.003	4/80
20	9.150	5/80
21	6.995	6/80
22	8.126	7/80
23	9.259	8/80
24	10.321	9/80
25	11.580	10/80
26	13.888	11/80
27	15.661	12/80
28	14.724	1/81
29	14.905	2/81
30	13.478	3/81
31	13.635	4/81

Mean: 11.05280645

Minimum Value: 6.99500000

Standard Deviation: 2.44052737

Maximum Value: 15.66100000

C.V.: 22.081

Range: 8.66600000

Source: Citibank Data Tape.

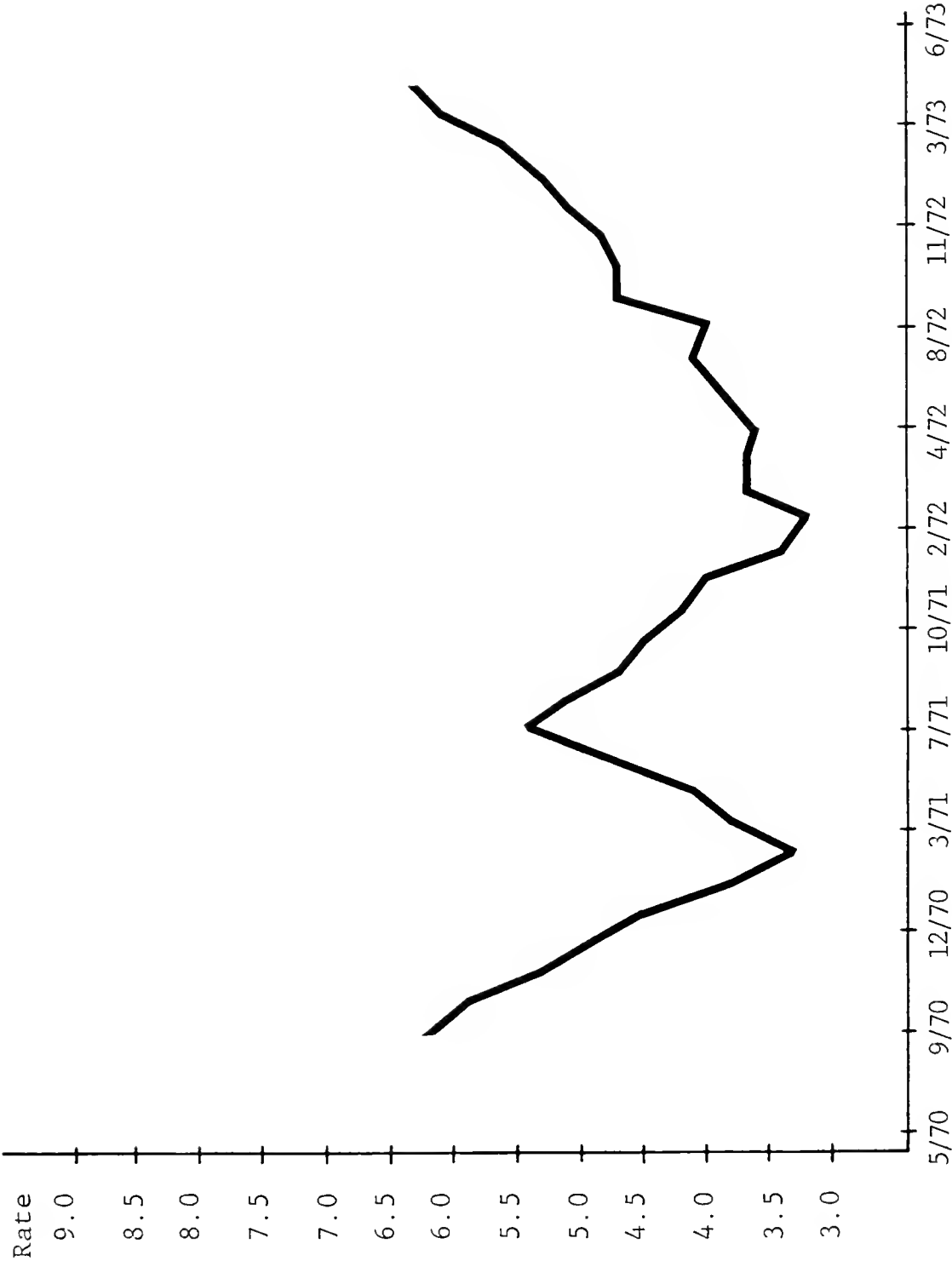


FIGURE 2  
MONTHLY TBILL RATES, PERIOD 1, 9/70-4/73

Source: Citibank Data Tape.

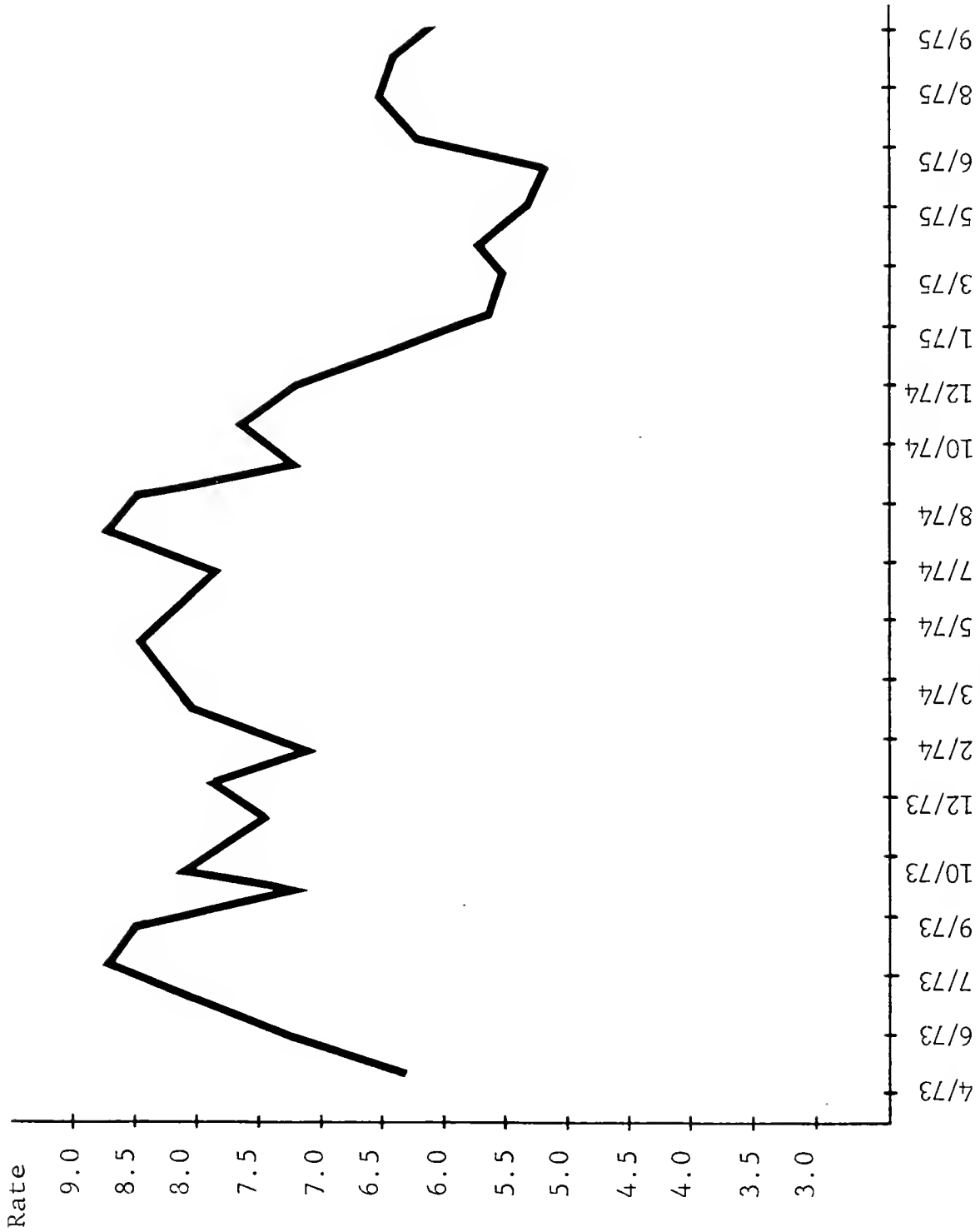


FIGURE 3  
MONTHLY TBILL RATES, PERIOD 2, 5/73-10/75  
Source: Citibank Data Tape.

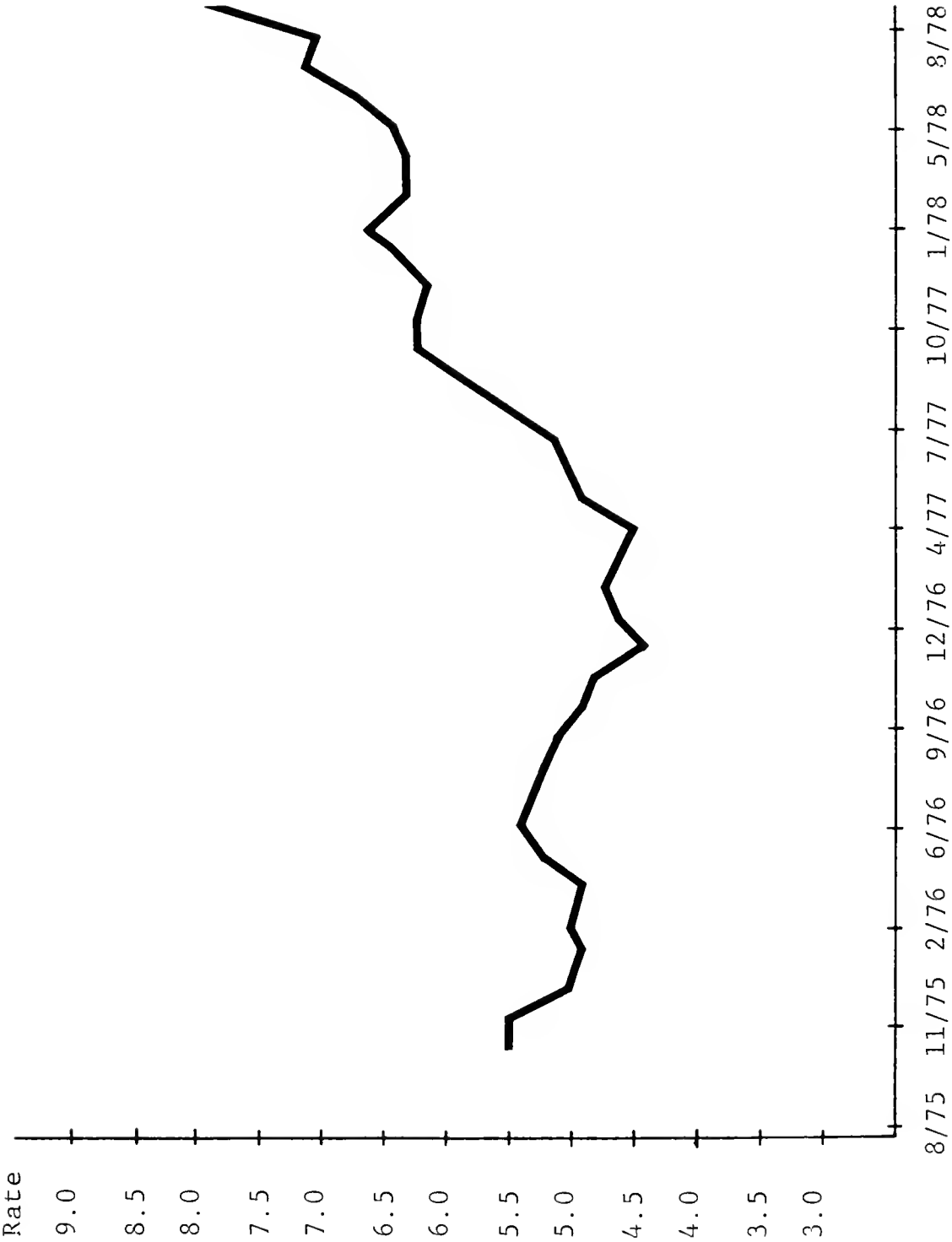


FIGURE 4  
MONTHLY TBILL RATES, PERIOD 3, 11/75-9/78

Source: Citibank Data Tape.

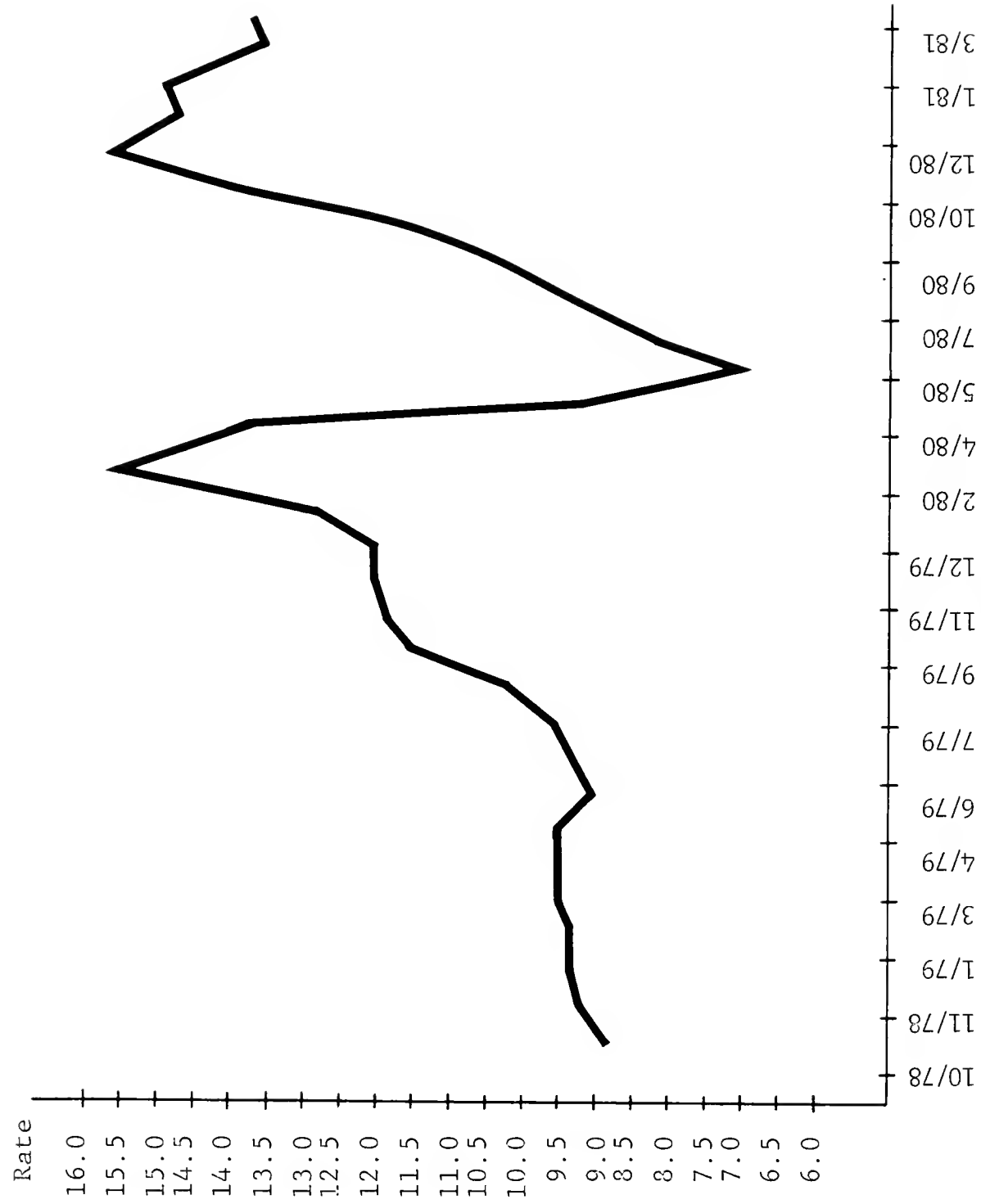


FIGURE 5  
MONTHLY TBILL RATES, PERIOD 4, 10/78-4/81  
Source: Citibank Data Tape.

TABLE 7  
AUCTION-DAY YIELDS ON 13-WEEK TBILLS

Period	Stock Market Volatility*	Date	Sample Size	Mean	Variance	Coeffi- cient of Variation	Range	Max.	Min.
1	$3.6 \times 10^{-5}$	10/72-4/73	30	5.42	0.334	.1065	1.77	6.45	4.66
2	$1.3 \times 10^{-4}$	5/73-10/75	131	7.07	1.25	.1581	4.68	9.54	4.88
3	$3.8 \times 10^{-5}$	11/75-9-78	152	5.53	.740	.1556	3.89	8.13	4.26
4	$8.0 \times 10^{-5}$	10/78-12/80	117	10.45	4.74	.2085	10.39	16.51	6.16

\* Measured as the average estimated variance of daily returns.

Source: CRSP stock market data; TBill rates from DRI data base.

TABLE 8  
CHANGES IN AUCTION-DAY YIELDS ON 13-WEEK TBILLS

Period	Stock Market Volatility *	Date	Sample Size	Mean	Variance	Range	Maximum	Minimum
1	$3.6 \times 10^{-5}$	10/72-4/73	30	.050	.020	0.65	0.37	-0.28
2	$1.3 \times 10^{-4}$	5/73-10/75	130	.005	.156	3.16	1.1	-2.06
3	$3.8 \times 10^{-5}$	11/75-9/78	152	.016	.016	0.81	0.46	-0.35
4	$8.0 \times 10^{-5}$	10/78-12/80	117	.056	.300	3.60	3.60	-2.00

$$\frac{\hat{\sigma}_3^2}{\hat{\sigma}_1^2} = 0.80 \quad F_{30,.01}^{152} = 2.11 \quad \frac{\hat{\sigma}_4^2}{\hat{\sigma}_2^2} = 1.92 \quad F_{130,.01}^{117} = 1.53$$

$$F_{30,.05}^{152} = 1.68 \quad F_{130,.05}^{117} = 1.35$$

\* Measured as the average estimated variance of daily returns.

Source: CRSP stock market data; TBill rates from DRI data base.

Note: Measured as first-differences, auction day to auction day.

TABLE 9  
DAILY TBILL RATES  
(DISCOUNT BASIS)

<u>Period</u>	<u>Date</u>	<u>Volatility<sup>a</sup></u>	<u>Sample Size</u>	<u>Mean</u>	<u>Variance</u>	<u>Coeffi- cient of Variation</u>	<u>Range</u>	<u>Max.</u>	<u>Min.</u>
1	9/70-4/73	$3.6 \times 10^{-5}$	663	4.57	.749	.1895	3.56	6.55	2.99
2	5/73-10/75	$1.3 \times 10^{-4}$	634	7.14	1.26	.1571	4.86	9.74	4.86
3	11/75-9/78	$3.8 \times 10^{-5}$	725	5.55	0.72	.1535	3.91	8.15	4.24
4	10/78-4/81	$8.0 \times 10^{-5b}$	641	10.96	5.92	.2220	10.96	17.14	6.18

<sup>a</sup>Measured as the average estimated variance of daily returns.

<sup>b</sup>10/78 to 11/80.

Source: CRSP stock market data; TBill rates from Board of Governors, Federal Reserve System.



TABLE 10  
CHANGES IN DAILY TBILL RATES  
(DISCOUNT BASIS)

Period	Date	Stock Market Volatility <sup>a</sup>	Sample Size	Mean	Variance	Range	Max.	Min.
1	9/70-4/73	$3.6 \times 10^{-5}$	633	-.00123	.00463	.55	.23	-.328
2	5/73-10/75	$1.3 \times 10^{-4}$	607	-.00209	.02586	1.59	.74	-.850
3	11/75-9/78	$3.8 \times 10^{-5}$	691	.00279	.00316	.58	.39	-.19
4	10/78-4/81	$8.0 \times 10^{-5}$ <sup>b</sup>	610	.00859	.05662	2.30	1.03	-1.27

$$\begin{array}{l} \hat{\sigma}_3^2 = 1.00 \quad \hat{\sigma}_4^2 = 2.19 \quad \text{Critical } F_{.05} = 1.00 \\ \hat{\sigma}_1^2 = 0.68 \quad \hat{\sigma}_2^2 \end{array}$$

<sup>a</sup>Measured as first-difference of daily rates.

<sup>b</sup>10/78 to 11/80.

Source: CRSP stock market data; TBill rates from Board of Governors,  
Federal Reserve System.

TABLE 11  
DEPENDENT VARIABLE IS THE MONTHLY OBSERVATION OF THE  
ONE MONTH PERCENTAGE CHANGE IN THE CPI

Period of Time	Coefficient Estimates									
	C <sub>0</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	D.W.	R <sup>2</sup>	$\hat{\rho}$
1/65-7/71	-1.04 (-0.75)	0.10 (0.81)	0.03 (0.22)	0.89 (1.36)	0.75 (1.14)	0.79 (2.86)	-0.17 (-0.40)	2.04	0.22	
8/71-4/74 (Wage-Price Controls)	-10.26 (-3.10)	-0.26 (-1.45)	0.15 (0.84)	3.02 (1.32)	3.67 (1.57)	2.51 (3.66)	0.54 (0.57)	2.00	0.58	
5/74-11/80	-1.03 (-0.98)	0.43 (4.31)	0.12 (1.17)	0.66 (1.18)	1.13 (2.26)	0.53 (3.42)	1.30 (4.28)	1.89	0.63	
9/70-4/81										

Equation estimated is  $INF_t = C_0 + C_1 INF_{t-1} + C_2 INF_{t-2} + C_3 GMIA_{t-1} + C_4 GMIA_{t-2}$

+  $C_5 r_{t-1} + C_6 Q_{t-1} + \epsilon_t$

where  $INF_t$  = actual inflation rate over time  $t$  to  $t+1$ ,  $GMIA_t$  = actual growth rate in money supply (MIA) from  $t-1$  to  $t$ ,  $r_t$  = actual 90-day TBill rate at time  $t$ ,  $Q_t$  = percentage growth in real personal disposable income. Estimation procedure is OLS. All observations are monthly. Inflation rates and interest rates are annualized.  $\hat{\rho}$  is the estimated correlation between  $INF_t$ , the predicted inflation rate from the regression equation, and the actual three-month inflation rate.

TABLE 12  
DEPENDENT VARIABLE IS MONTHLY OBSERVATION  
OF 90-DAY TBILL RATE

Time Period	Coefficient Estimates						Sample Size
	$\lambda_0$	$\lambda_1$	$\lambda_2$	$\lambda_3$	$\rho$	$\sigma^2_{\epsilon}$	
5/65-4/81	- 24.01 (3.11)	19.74 (5.50)	-7.00 (-3.37)	0.15 (4.78)	.649	.586	194
1. 9/70-4/73	- 50.26 (-0.29)	9.68 (0.35)	-0.33 (-0.12)	0.19 (2.56)	.352	.356	33
2. 5/73-10/75	140.55 (2.47)	0.76 (0.11)	-10.57 (-1.53)	0.03 (0.83)	.443	.421	31
3. 11/75-9/78	-117.04 (-2.59)	12.45 (0.85)	3.33 (0.73)	0.01 (0.10)	.762	.094	36
4. 10/78-4/81	-541.85 (-2.01)	-16.57 (-0.80)	48.06 (1.64)	0.31 (2.60)	.519	1.479	32

Estimation results from equation (5),  $r_t = \lambda_0 + \lambda_1(y_{ct} - m_t + p_{t-1}) + \lambda_2 z_t + \lambda_3 \pi_t^e + \epsilon_t$ .

Note that  $z_t = \log$  (federal debt outstanding),  $y_{ct} = \log$  (real capacity output),  $m_t = \log$  (money supply),  $\pi_t^e = \text{expected inflation}$ ,  $p_t = \log$  (CPI),  $\rho$  is the estimated first-order autocorrelation coefficient.

TABLE 13  
DEPENDENT VARIABLE IS THE MONTHLY OBSERVATION  
OF THE 90-DAY TBILL RATE

Time Period	$\lambda_0$	$\lambda_1$	$\lambda_3$	$\rho$	$\sigma_\epsilon^2$	$R^2$	Sample Size
5/65-4/81	-46.94 (-7.49)	8.61 (8.36)	0.09 (3.16)	.751	.503	.36	194
1. 9/70-4/73	-52.84 (-0.33)	9.40 (0.35)	0.18 (2.56)	.364	.340	.21	33
2. 5/73-10/75	57.84 (2.71)	-8.32 (-2.40)	0.03 (0.82)	.498	.426	.21	31
3. 11/75-9/78	-132.92 (-3.39)	22.06 (3.53)	0.02 (0.52)	.763	.093	.29	36
4. 10/78-4/81	-101.10 (-3.15)	16.71 (3.39)	0.35 (2.86)	.568	1.548	.38	32

Estimation results from  $r_t = \lambda_0 + \lambda_1(y_{ct} - m_t + p_{t-1}) + \lambda_3\pi_t^c + \epsilon_t$   
Variables as defined in Table 6.

TABLE 14  
DEPENDENT VARIABLE IS THE MONTHLY OBSERVATION  
OF 90-DAY TBILL RATE

Time Period	$B_0$	$B_1$	$B_2$	$B_3$	$B_4$	$B_5$	$\rho$	$\sigma^2_\eta$	$R^2$	Sample Size
5/65-4/81	-10.35 (0.67)	-35.90 (-7.05)	0.12 (4.01)	-0.71 (-0.41)	48.14 (7.43)	-25.12 (-6.09)	.622	.489	.62	194
1. 4/70-4/73	-330.68 (-2.16)	-59.69 (-2.72)	0.13 (2.22)	17.46 (1.46)	68.91 (3.97)	-56.16 (-2.72)	.319	.242	.54	33
2. 5/73-10/75	-20.60 (-0.39)	-37.88 (-2.67)	0.05 (1.45)	4.07 (0.80)	26.72 (2.94)	-32.60 (-5.83)	-.003	.255	.82	31
3. 11/75-9/78	-72.88 (-0.93)	-2.05 (-0.10)	0.03 (0.49)	-3.38 (-0.64)	34.00 (2.37)	-15.85 (-1.10)	.471	.144	.55	36
4. 10/78-4/81	-863.35 (-3.90)	54.63 (2.19)	0.39 (3.88)	70.55 (4.31)	54.26 (1.36)	-63.46 (-2.33)	.224	1.170	.76	32

Estimation results from equation (8),  $r_t = B_0 + B_1 \text{LRMB}_t + B_2 \Pi_t^e + B_3 \text{LPD}_t + B_4 \text{LPDI}_t + B_5 \text{LP}_t + \eta_t$ .  
 Note that  $\text{LRMB}_t = \log$  (real monetary base),  $\Pi_t^e = \text{expected inflation}$ ,  $\text{LPD}_t = \log$  (federal debt outstanding),  $\text{LPDI}_t = \log$  (real personal disposable income),  $\text{LP}_t = \log$  (potential real personal disposable income),  $\rho$  is the estimated first-order autocorrelation coefficient.

TABLE 15  
DEPENDENT VARIABLE IS THE QUASI-DIFFERENCED MONTHLY  
OBSERVATION OF THE 90-DAY TBILL RATE

<u>Time Period</u>	<u>A<sub>1</sub></u>	<u>A<sub>2</sub></u>	<u>A<sub>3</sub></u>	<u>R<sup>2</sup></u>	<u>σ<sup>2</sup></u>
9/70-4/81	-6.85 (-0.22)	8.43 (0.31)	0.55 (0.68)	0.25	1.64
1. 9/70-4/73	15.33 (0.20)	5.90 (0.10)	0.15 (0.48)	0.49	0.20
2. 5/73-10/75	-77.47 (-1.65)	27.62 (0.73)	-0.05 (-0.20)	0.47	0.64
3. 11/75-9/78	22.32 (0.67)	21.70 (0.73)	0.18 (1.52)	0.70	0.16
4. 10/78-4/81	-181.54 (-1.25)	308.89 (1.08)	0.19 (0.31)	0.26	5.54

Estimation results from the quasi-differenced form of the model (5) and (6). See in general equations (13) and (15).

Estimate of  $\hat{\rho}$  is from instrumental variables estimation.

Instrumental variables estimation.  $\hat{\rho} = 0.910$

## CHAPTER 5

### SUMMARY AND CONCLUSIONS

This study was designed to provide evidence on the spot price volatility effects of TBill futures trading. The study was motivated by the concerns of the Federal Reserve System and the Treasury Department that futures trading in Treasury instruments will have negative impacts on the spot markets in these instruments. In particular, the Federal Reserve/Treasury Study (1979) voiced the concern that futures trading would increase the volatility of spot interest rates on Treasury instruments and hence raise the cost of the Government's debt financing. This study empirically examined the spot rate volatility effects of TBill futures trading to see if this concern was borne out by the behavior of spot rates.

This issue is of some importance for two very practical reasons. First, futures trading in other commodities (onions) has been banned, demonstrating that the threat of prohibition of Treasury instrument futures markets is very real. Second, these markets, and particularly the TBill market, are very successful futures markets. There would therefore be many people adversely affected by their

prohibition. Charges of ill effects caused by these markets deserve careful attention and evaluation.

Previous empirical studies on the spot price effects of futures trading generally suffer from failure to hold other things constant in comparing spot price characteristics during periods with and without futures trading. In this study that problem was overcome in two steps. First, the data were split into four subperiods based on general capital market volatility. The four subperiods provided two pairs of comparable time periods, comparable in terms of their overall capital market volatility. One pair had relatively low volatility and the other pair had relatively high volatility. Each pair had one subperiod before and one subperiod after the introduction of TBill futures trading (January, 1976). The capital market volatility was measured by the estimated variance of daily stock market returns, by month, and by the estimated variance of daily TBond yields, by month. Comparable periods 1 and 3 were 9/70-4/73 and 11/75-9/78, respectively. Comparable periods 2 and 4 were 5/73-10/75 and 10/78-4/81, respectively. Periods 1 and 3 had lower overall capital market volatility than periods 2 and 4 (see Table 7), hence periods 1 and 3 were dubbed "calm" and periods 2 and 4 were dubbed "volatile."

The second step followed to hold other things constant was to use multiple regression analysis to explain



the variations in monthly TBill rates due to factors other than the presence or absence of futures trading. To this end, two models of interest rate determination were applied to the monthly data in each of the four subperiods. Two models were used to represent the two approaches to econometric models of interest rate behavior. One estimating equation is the reduced form equation from a simultaneous equations macroeconomic model of the economy, due to Sargent (1973) and similar to the model in Bomberger and Frazer (1981). The second estimating equation is representative of the partial equilibrium approaches to interest rate models in several papers, notably Okun (1963), Feldstein and Eckstein (1970) and Feldstein and Chamberlain (1973).

To assess the spot price volatility effects of futures trading involved pairwise comparisons of measures of the random fluctuations in TBill rates between comparable periods before and after the introduction of TBill futures trading. The measures used were the estimated variances and coefficients of variation of the random disturbance terms in the two interest rate estimating equations. Additionally, total variances and coefficients of variation of daily TBill rates were computed to compare to the results from the regression equations and to provide continuity with the methodology used in earlier studies of price effects of futures trading.

The results from the coefficients of variation of daily TBill rates show that the futures trading period 3 has less volatility than the before-futures period 1 while futures trading period 4 had higher volatility than period 2.<sup>1</sup> (Recall that periods 1 and 3 were comparable in terms of overall capital-market volatility, and that periods 2 and 4 were comparable.) The same results hold for the variances of first-differences in daily and auction-day TBill rates.

These results cannot be used to draw conclusions about the price volatility effects of futures trading because they do not satisfy the ceteris paribus requirement. The results from the regression models do satisfy this requirement. The first set of regressions were estimated under the assumption that a constructed series on expected inflation (described on pages 91 and 92 Chapter 4) was equal to the true (unobservable) expected inflation series. The results are presented in Tables 12 and 14. The variances and coefficients of variation for the disturbance term in each period are shown on page 95, Chapter 4. They reflect the same pattern as the simple analysis in Tables 7 -10. "Calm" futures trading period 3 had lower volatility than "calm" no-futures period 1; the reverse

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<sup>1</sup>The coefficients of variation for auction-day rates show that the volatility for both futures trading periods is higher than the before-futures periods. However, the data do not cover the entire first or fourth periods and so are not really comparable.

is true for "volatile" futures period 4 versus "volatile" no-futures period 2. This pattern is uniform across the two variants of the macroeconomic system reduced form models and the partial equilibrium model, and uniform across the two measures of volatility.

Relaxing the assumption that the constructed expected inflation series was equal to unobserved true expected inflation series required a more involved estimation procedure, based on the instrumental variable technique and on the Rational Expectations Hypothesis. The results from this estimation procedure are presented in Table 15. On pages 103 and 104 of Chapter 4 the variances and coefficients of variation from this procedure are compared for the comparable subperiods. The pattern is the same as for the other estimation procedure. The volatility of period 3 is less than period 1 while the volatility of period 4 exceeds the volatility of period 2.

To be able to state strongly that futures trading does or does not increase the spot market volatility of TBills would require the same result from both pairs of comparable subperiods. This did not turn out to be the case. Collectively, the actual results indicate that futures trading does not increase the volatility of the spot TBill market when the overall capital market conditions are relatively calm but does increase the spot market volatility when overall capital market conditions are relatively volatile.

Results such as these are difficult to interpret. One reasonable interpretation follows the same idea as Kaldor's argument for destabilizing speculation. (See pages 51 and 52 in Chapter 2.) When capital markets are, in general, becoming more volatile, larger potential "one shot" profits are offered by futures market speculation. These larger profits may lure more uninformed individuals, without sufficient expertise, into taking speculative futures positions. The ill-informed speculators make the spot TBill market more volatile by signalling incorrect information to spot market/futures market participants (broadly, hedgers). When capital markets are relatively calm, possible speculative gains on a "one shot" basis are less spectacular and hence the TBill futures market attracts fewer "gamblers"--ill-informed speculators.<sup>2</sup>

One policy implication of this interpretation is that fiscal and monetary actions should not vary so much as to greatly increase the capital market volatility and encourage uninformed speculation in the futures market. Note that, for example, the variance of the monthly real monetary base for period 4 is more than three times the variance for period 2, and the coefficient of variation for period 4 is twice as large as for period 2.

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<sup>2</sup>It is important to note that such a theory would be very hard to test directly since the level of futures market activity provides no evidence on volatility effects. Futures market activity should generally rise with spot market volatility since the costs of not hedging rise with volatility. In fact, sufficient volatility in the spot market is a prerequisite for a successful futures market.

Since futures trading is associated with increased spot rate volatility only when overall capital market volatility is high, futures trading alone cannot be said to cause higher spot rate volatility. Thus, the results presented here do not imply a policy of prohibiting futures trading in Treasury instruments. Most importantly, the mixed results indicate the need for further study of Treasury instrument futures before any decision is made about the prohibition of these markets. The direction of further study should be towards more complete models of interest rate behavior.

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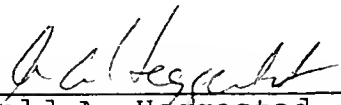
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## BIOGRAPHICAL SKETCH

David Cohen was born November 1953 in Jacksonville, Florida. He graduated from Winter Park High School, Winter Park, Florida, in 1971. He attended University of Florida from 1971 to 1975 receiving the Bachelor of Arts degree (economics) in 1975. In 1977 he received the Master of Arts degree (economics) from University of Florida. The requirements for the Doctor of Philosophy (finance) were completed in August 1982 at the University of Florida.

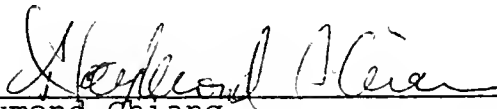
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\_\_\_\_\_  
Arnold A. Heggstad, Chairman  
Professor of Finance

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

  
\_\_\_\_\_  
G.S. Maddala  
Graduate Research Professor  
of Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

  
\_\_\_\_\_  
Raymond Chiang  
Assistant Professor of Finance

This dissertation was submitted to the Graduate Faculty of the Department of Finance, Insurance, and Real Estate in the College of Business Administration and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August, 1982

\_\_\_\_\_  
Dean for Graduate Studies  
and Research

